



THE
Q U A R T E R L Y
J O U R N A L
OF
THE CHEMICAL SOCIETY
OF
L O N D O N.

Committee of Publication.

T. GRAHAM, F.R.S. A. W. HOFMANN, PH.D., F.R.S.
W. A. MILLER, M.D., F.R.S. A. W. WILLIAMSON, PH.D.

VOL. V.

LONDON:
HIPPOLYTE BAILLIÈRE, 219, REGENT STREET,
AND 290, BROADWAY, NEW YORK, U.S.
PARIS: J. B. BAILLIÈRE, RUE HAUTEFEUILLE.
MADRID: BAILLY BAILLIÈRE, CALLE DEL PRINCIPE.
1853.

5-361
25-9/90
B

LONDON:
Printed by Schulze and Co., 13, Poland Street.

QD
|
C6
V. 5-6
COP 3

CONTENTS

OF

THE FIFTH VOLUME.

	PAGE
On the Decomposition of Citrate of Lime in contact with putrefying Curd. By Henry How, Esq.	1
On Populin. By Rafaëlle Piria	8
On the variation in the relative proportion of Potash and Soda present in certain samples of Barley, grown in plots of ground artificially impregnated with one or other of these Alkalies. By Charles Daubeny, M.D., F.R.S.	9
On the Compounds of Cotton with the Alkalies. By J. H. Gladstone, Ph. D.	17
On the occurrence of Capric and Caprylic acids in some Fusel oils. By Thomas H. Rowney, F.C.S.	22
On the oxidation of Chinese Wax. By Nevil S. Maskelyne, M.A.	24
On a quick approximative method of estimating minute quantities of iron by means of a Colorimeter. By Thornton J. Herapath	27
On Dr. Keller's supposed formation of Metacetic Acid from Flour and Leather. By R. W. Forster	28
Proceedings at the Meetings of the Chemical Society	29
Notices of Papers in British and Foreign Journals:	
Chemical Report on the cause of the Fire in the 'Amazon.' By Professor Graham	34
Contributions to the knowledge of the Manufacture of Gas. By E. Frankland, Ph.D.	39
On the Products of the destructive distillation of animal substances, Part II. By Thomas Anderson, M.D., F.R.S.E.	50
On Rubian and its Products of Decomposition, Part I. By Edward Schunk, F.R.S.	56
On Aspartic and Malic Acids. By L. Pasteur	62
Organic Bases containing Antimony	66
Observations on Telluric Ethyl, or Telluride of Ethyl. By W. Mallet	71
Examination of certain products obtained from Hippuric Acid. By N. Socoloff and A. Strecker	73
On a new method of separating substances possessing very similar properties. By W. Heintz	82
On the composition of Human Fat. By W. Heintz	84

On a new compound of Mercury. By Sobrero and Selmi	86
On Ethylmercuric Nitrate. By Ch. Gerhardt	88
On the Allotropy of Selenium. By Dr. Hittorff	90
On Phosphide of Tungsten. By Wöhler	94
On the composition of Wolfram. By J. Persoz	95
On a New Method of obtaining Hippuric Acid in considerable quantity without evaporation of the Urine; and on some of its Products of Decomposition. By Edward Riley, F.C.S.	97
Contributions towards the history of Tannic Acid. By Dr. Strecker	102
On the detection and qualitative separation of Tin, Antimony, and Arsenic; and on the relation existing between these metals, and others which are precipitated from their acid solutions by Sulphuretted Hydrogen. By Charles L. Bloxam	104
Researches on the Constitution of Organic Acids. By M. Charles Gerhardt	127
Note on the Preparation of Carbonate of Amyl. By John A. Bruce	131
New Formation of Salicylic Acid. By H. Gerland	133
Chemical Memoranda. By Robert Warington	136
I. On a curious form of Crystallization of Iodide of Potassium	136
II. On a method of detecting qualitatively, small quantities of Oxide of Copper in solution	137
III. Some additional observations on the Green Teas of commerce	139
IV. A modification of the ordinary process of sublimation in a straight tube	141
On the Action of Ammonia upon Binoxysulphocarbonate of Amyl. By Matthew W. Johnson.	142
On a New Process for the Detection of Fluorine when accompanied by Silica. By George Wilson, M.D.	151
Proceedings at the Meetings of the Chemical Society	153
Notices of Papers contained in other Journals :	
Report upon the Alleged Adulteration of Pale Ales by Strychnine. By Professors Graham and Hofmann	173
On the Polarizing Crystals produced by the action of Iodine on the Sulphate of Quinine. By Dr. Herapath	177
On a Method of obtaining a perfect Vacuum in the Receiver of an Air-pump. By Thomas Andrews, M.D., F.R.S., M.R.I.A.	189
Note on the existence of Strontia in the Well-Waters of Bristol. By Messrs. William Herapath and Thornton J. Herapath	193
A New Method for the analysis of Chrome Ores. By F. C. Calvert	194
On certain Isomeric Transformations of Fats. By Patrick Duffy	197
On the Qualitative Separation of Arsenic, Tin and Antimony. By George F. Ansell	210
Observations upon a New Series of Double Chlorides containing Diplatossammonium. By G. B. Buckton, F.L.S.	213
On the Acid Oxalates of the Earths. By Edward Clapton	223
Researches on the Anhydrous Organic Acids. By Charles Gerhardt	226
Notices of Papers contained in other Journals :	
Report upon "Original Gravities." By Professors Graham, Hofmann and Redwood	229
Researches on some of the Crystalline Constituents of Opium. By Thomas Anderson, M.D., F.R.S.E.	257

CONTENTS.

V

	PAGE
On the Extraction of Oxygen Gas from Atmospheric Air. By M. Boussingault	269
Electro-Chemical Researches on the Properties of Electrified Bodies. By E. Frémy and E. Becquerel	272
On the Preparation of Pure Acetic Acid from Wood-Vinegar and Brandy-Vinegar. By C. Völkcl	274
On Enanthic Ether and Enanthic Acid. By W. Delffs	279
On Sorbine, a New Saccharine Substance, extracted from the Berries of the Mountain-Ash. By J. Pelouze	281
On the Constitution of Citric Acid. By L. Pebal	284
On the Occurrence of Trimethylamine in Herring-brine. By Dr. Hofmann	288
On the Action of Iodine upon Phosphorus. By B. C. Brodie, F.R.S.	289
On the Valuation of Indigo. By Dr. Frederick Penny, F.C.S.	297
On the Constitution of Stearine. By Patrick Duffy	303
On the Compounds of several Essential Oils with the Alkaline Bisulphites. By Cesare Bertagnini	317
Proceedings at the Meetings of the Chemical Society	319
Titles of Chemical Papers in British and Foreign Journals, published in the year 1852	323
Index	378

ERRATA.

Page 63 line 3, for malic acid <i>read</i> aspartic acid.
„ 63 „ 22, for service-tree <i>read</i> mountain-ash.
„ 66 „ 14, for service-tree <i>read</i> mountain-ash.
„ 68 „ 4 from bottom, for iodine <i>read</i> iodide.
„ 101 „ 14, for <i>c</i> is common to the zones <i>eb</i> , <i>va</i> , <i>read a</i> is common, &c.
„ 102 „ 17, for all <i>read</i> also.



THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

I.—*On the Decomposition of Citrate of Lime in contact with putrefying Curd.*

By HENRY HOW, Esq.

ASSISTANT TO DR. THOS. ANDERSON OF EDINBURGH.

The following notes are intended as a contribution to the knowledge already existing of the decompositions produced in complex organic molecules by contact of fermenting substances. Although in the present instance the study of the subject is incomplete, for reasons to be specified, I thought the few facts in my possession sufficiently interesting to be made known in the mean time, as a number of experiments of the nature to be described, sufficient for supplying the whole of the information sought, will possibly occupy a very long period.

The subject of the peculiar action set up in bodies by contact of ferments and putrescents has proved very interesting, and, in the case of the organic acids, the results as yet obtained present considerable uniformity. From experiments of this nature made with some of the vegetable acids, and acids derived from them, we see succinic acid occurring as an almost constant product, accompanied in some instances by one or other of the acids $C_n H_n O_4$. Thus Dessaignes* has shown that malate of lime yields succinic acid, and Liebig† that acetic and sometimes butyric acid occur in the same process, the formation of either of these volatile acids depending on the relative proportion of ferment and salt employed. The former chemist has

* Compt. Rend. XXVIII, 16.

† Ann. Ch. Pharm. LXX, 104.

further shown* that fumaric, maleic, and aconitic acids all yield succinic acid under the same circumstances; but he does not mention whether he observed the formation of volatile acids. He remarks, however, that citrate of lime and citrate of soda afford no succinic acid.

Tartrate of lime was submitted to a similar trial some few years ago by Nöllner.† He suffered this salt, as prepared from crude tartar, to undergo spontaneous fermentation, and he obtained a volatile product which he termed *pseudo-acetic acid*.

Consideration of the foregoing facts, induced me to examine more particularly the change produced upon citric acid by contact with a putrescent body.

The experiments I am about to detail were performed in Dr. Anderson's laboratory, in Edinburgh.

Some crystallized commercial citric acid was powdered up with an excess of chalk and some water to a thin paste. When effervescence had ceased, dried curd to the amount of a fourth part of the acid employed was beaten up with the mixture, which was then transferred, along with about ten times its bulk of water, to a glass flask. This was furnished with a gas-evolution tube, and placed in a warm situation, where a thermometer immersed in the mixture indicated a temperature varying between 80° and 100° Fah. The whole began to stink in three days, and in about ten days fermentation seemed at its height; the gases evolved were carbonic acid and hydrogen, and at this period the former stood to the latter in the ratio of two volumes to one; the quantity of gaseous product afterwards decreased, and the relative proportions of the individual gases changed, the hydrogen preponderating. Of the last portions of gas collected about three volumes in four were hydrogen. The process was stopped on the twenty-second day, when a large amount of lime was found to be in solution, while a slimy sediment remained at the bottom of the flask, containing the undecomposed curd, and the excess of chalk. I could detect no succinic acid.

The fluid was filtered off, and precipitated by carbonate of soda; the filtrate from the carbonate of lime was evaporated to a very small bulk; the syrupy fluid on being allowed to cool, became a nearly solid mass, without exhibiting any distinct signs of crystallization. It was diluted with water and distilled with an excess of sulphuric acid, the products being carefully condensed in a Liebig's apparatus. The fluid which passed over had a strong acid reaction, and smelt of a *fatty* acid; the distillation was continued till about half of the

* Compt. Rend. XXXI, 432.

† Gmelin Handbuch, Band V, 116.

contents of the flask had evaporated. The product was received, in three separate portions: the first, on the commencement of the distillation, showed a slight opalescence, apparently caused by the presence of an oily substance, possibly a little "ferment oil;" this, however, soon disappeared, and the whole of the fluids collected were clear and homogeneous.

A silver-salt was made from the first portion by neutralizing as nearly as possible with ammonia, and addition of nitrate of silver. A copious white flocky precipitate fell; it was collected and washed with cold water. On attempting to re-crystallize it from boiling water, it was found that while the greater part dissolved, considerable colouration took place, and a small portion remained black and undissolved. The filtered fluid was not completely colourless; however, it deposited a salt in white rounded granules, which, under strong magnifying power, presented a peculiar appearance, resembling the form of sassafrage or lycopodium. It was found to withstand the action of light, remaining perfectly white after some days' exposure, but was speedily blackened at a temperature of 212° Fah.; it was therefore dried in vacuo for analysis:

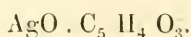
I. 5.402 grains gave :	
3.295 „	carbonic acid, and
1.175 „	water,
4.278 „	gave, on ignition,
2.675 „	metallic silver.

A second salt was made from the same portion of the distillate in the same manner, but it was not recrystallized; of this,

II. 5.800 grains, dried in vacuo, gave on ignition
3.578 „ silver.

	I.	II.	Mean.			
Carbon	16.63			17.23	C ₅	30
Hydrogen	2.51			2.29	H ₄	4
Oxygen				18.39	O ₄	32
Silver	62.52	61.68	62.10	62.09	Ag	108.1
	100.00	100.00	100.00	100.00		174.1

Although the above results differ somewhat from the theory given, the discrepancy is not remarkable when the decomposable nature of the salt is taken into account; and this allowance being made, the constitution of the salt is most simply represented by the formula,



Interested by this apparently anomalous formula, I endeavoured to obtain the acid *per se*, by forming in the first place its lead-salt, and then distilling with strong sulphuric acid. For this purpose, I saturated as nearly as possible the remainder of the first portion of the distillate with carbonate of lead, and evaporated the fluid so obtained to a very small bulk in the water-bath; a syrup remained, which after a considerable time became an opaque and crystalline solid mass. A portion of this was found continually to lose weight by protracted heating at 212° , the acid apparently going off. The remainder of it was distilled with strong sulphuric acid; a pungent acid liquor was obtained, but its quantity was too small to admit of any experiments to determine its boiling-point, &c.; it was therefore saturated with carbonate of soda, and nitrate of silver was added to the solution; a salt was obtained agreeing closely in its external characters with that already described; it was analysed:

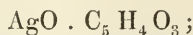
6.167	grains, dried in vacuo, gave:
3.855	„ carbonic acid, and
1.435	„ water,
4.483	„ dried in vacuo, gave, on ignition,
2.802	„ silver.

The percentage calculation from these numbers gives a close approximation to those before obtained:

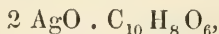
	Found.	Theory.
Carbon	17.07	17.23
Hydrogen	2.58	2.29
Oxygen	17.85	18.39
Silver	62.50	62.09
	100.00	100.00

and these results show that, whatever may be the nature of the acid, it remains unchanged during the whole of the processes above-mentioned.

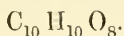
As before remarked, the most simple formula expressive of the constitution of the silver-salt, is



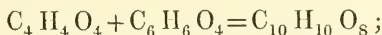
this is, however, an improbable constitution, and the formula requires to be doubled to assume a more reasonable character; if this be done, we obtain



which would be the representation of a neutral salt of a bibasic acid,



Such a substance has not as yet been met with in an isolated state ; but two salts are described,* which undoubtedly contain the elements in proportions corresponding to such a formula, and the method of their formation indicates clearly the nature of the acid in question. They are produced by mixing together salts of acetic and of propionic acids ; the first is a soda-, the other a silver-salt, which last agrees in such of its characters as are described, with those mentioned above, excepting perhaps the slight difference that its crystals are described as dendritic. I consider, therefore, this acid to be what may be called the aceto-propionic, being made up of an atom of each of these acids coupled together :



its bibasic nature is thus accounted for, and its formation meets with a curious parallel in the case of the pseudo-acetic acid of Nöllner.

This chemist† obtained by the fermentation of tartrate of lime, as prepared from crude tartar, a volatile acid which he termed pseudo-acetic acid. He described some of its salts, but did not analyse them. Nicklès,‡ however, undertook an investigation, from the results of which he concluded the acid to be a conjugate compound of butyric and acetic acids ; he named it accordingly butyro-acetic acid. Berzelius considered it as a mixture of these two, while Dumas, Malaguti, and Leblanc, pronounced it to be identical with metacetic (propionic) acid. However, from the decided character of some of the salts described, and the fact of the acid separating into butyric and acetic acids, neither of these views appears to be well founded.

The existence of the acid derived from citric acid lends a support to the original position of Nicklès, and furnishes another instance of the tendency of the acids $\text{C}_n \text{H}_n \text{O}_4$ to form coupled compounds. Viewed in this light, it is the lowest term yet known of a series of homologous conjugate acids, of which many members are wanting to render it complete. The properties of Lerch's§ vaccinic acid appear, upon consideration of the evidence, to class it among these bodies, although the amount of baryta found in the salt examined, differs

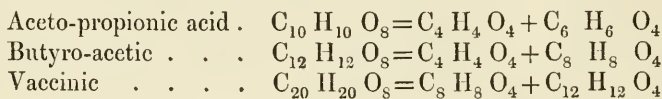
* Gmelin Handbuch, Band V, 112, 113.

† Ann. Ch. Pharm. XXXVIII, 299. Gmelin Handbuch, V, 115.

‡ Gmelin, V, 116.

§ Ann. Ch. Pharm. XLIX, 227.

somewhat from that corresponding to an acid composed of butyric and caproic acids. The circumstance of these acids being produced upon simple exposure to the air, and the identity of the saturating capacity of vaccinic acid with that of both the others, seem to overrule what may be an accident, and prove the acid to be a coupled body of the nature in question. This admitted, the terms of the series as yet known are :



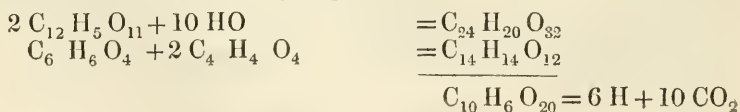
It was mentioned that the acid distillate from the soda-salt was received in three portions. Silver-salts were made from the two last in the same manner as from the first; they were decidedly more crystalline in appearance. A determination of the silver was made.

from II.	{ 4·702 grains, dried in vacuo, gave 3·010 „ silver.			
from III.	{ 5·270 „ dried in vacuo, gave 3·385 „ silver.			
Carbon		14·36	C ₄	24
Hydrogen		1·19	H ₃	3
Oxygen		19·76	O ₄	32
Silver	64·01	64·23	64·69	Ag 108·1
	100·00	100·00	100·00	167·1

which is sufficient to show them to have the composition of acetate of silver; the peculiar odour of the liberated acid, and other reactions, confirmed this result.

The fact is here illustrated, that in a mixture of acids of this series, the most volatile does not invariably pass over first; the instance of an acid mixture in certain proportions of acetate and valerianate of potash, when distilled, is another case in point.

The derivation of these acids may be explained by the following scheme: if we add to the equivalents of two atoms of anhydrous citric acid, as it exists in the neutral lime-salt, the elements of 10 atoms of water, we obtain those of one atom of propionic, 2 of acetic, 10 of carbonic acid, and 6 of hydrogen.



I made a second experiment upon a much larger scale, in the hope of obtaining a sufficient quantity of the aceto-propionic acid to enable me to study it more completely; but having somewhat varied the conditions, I obtained nothing but acetic acid. The details of the experiment are as follows:

Citric acid, as before, was neutralized with an excess of chalk, and curd to the amount of about a sixth part of the weight of the acid was added; the whole was mixed up to a thin paste with water, in an open glass vessel, which was then placed in a larger vessel of water, in which the temperature was kept constant at about 100° Fah., by means of a Kemp's apparatus. I observed, however, after fermentation had fairly commenced, that a thermometer immersed in the fermenting mass itself, always indicated a temperature about 10° higher than in the outer vessel. The process was continued between three and four weeks, at the end of which time, a quantity of filtered aqueous fluid was precipitated by sulphuric acid, and distilled. The product was received in three separate portions, as before; a silver-salt was made from the first.

7.315 grains, dried in vacuo, gave

4.710 „ silver;

the percentage calculated from this number is 64.38, while 64.69 is that of acetate of silver. Of a salt made from the last portion,

5.916 grains, dried in vacuo, gave

3.825 „ silver;

calculated percentage = 66.65. I obtained a similar result by making a salt by direct precipitation of the lime-salt by nitrate of silver, the percentage of silver in the purified salt was found to be 64.

It is obvious, from the foregoing facts, that the nature of the product varies according to the conditions of experiment, and the comparatively high temperature constantly sustained was undoubtedly the cause of the formation of acetic acid only in the last case; it is possible that, by operating at a much lower degree of heat, either propionic, or aceto-propionic acid alone may be generated. Other results might be obtained with different salts of citric acid, with bases wanting the affinity for carbonic acid possessed by lime; some acid salts also might furnish subjects for experiments. I am not at present in a condition to supply any information on this subject; but should I arrive at any interesting facts in prosecuting some inquiries in this direction, which necessarily extend over a considerable length of time, I shall offer them to the notice of the Society.

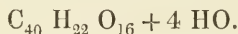
II.—On *Populin*.

BY RAFAELLE PIRIA.

(FROM A LETTER TO DR. HOFMANN.)

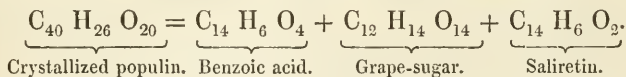
Since my return to Italy, I have been engaged with the investigation of a crystalline substance, discovered, as you will recollect, by Braconnot in the leaves and bark of *Populus tremula*, and described by this chemist under the name of *Populin*. The composition and the reactions of this compound have remained unknown up to the present moment. From the following note, which gives you the results I have as yet obtained, you will see that populin is closely connected with several of the best known series of organic chemistry.

The composition of populin is represented by

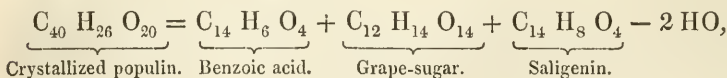


This formula, the result of direct analysis, is moreover confirmed by the deportment exhibited by this substance, when submitted to the influences of chemical agents.

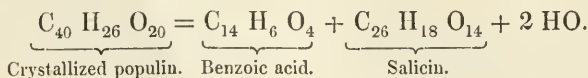
On heating populin with dilute acids, it is decomposed into benzoic acid, grape-sugar, and saliretin, and you will observe that the above formula of crystallized populin exactly represents the sum of the elements of one equivalent of each of these substances.



Since saliretin is a product of the action of acids on saligenin, populin may be viewed as a conjugate compound of benzoic acid with saligenin and grape-sugar.



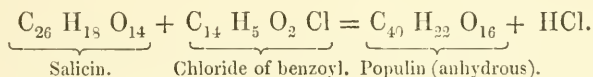
or, what amounts to exactly the same thing, as a conjugate compound of benzoic acid with salicin itself:



The relations which I have pointed out induced me to try whether

populin might not be converted into salicin. Nothing in fact is easier: it suffices to boil a solution of populin with baryta-water; you obtain a perfectly limpid liquid which contains nothing except benzoate of baryta and salicin. I have compared the chemical and physical properties of salicin thus obtained with those of the substances prepared from willow bark; they coincide in every point. Here then we have a very complex organic compound artificially produced by the decomposition of a still more complex substance.

My next step will be to transform, if possible, salicin into populin; I hope to effect this change by submitting it to the action of chloride of benzoyl.



The only difficulty which presents itself as yet, is the action of the hydrochloric acid, which is liberated in this process, on the newly-formed compound.

I need scarcely mention, that in boiling populin with a mixture of sulphuric acid and bichromate of potassa, you obtain a considerable quantity of hydride of salicyl.

III.—*On the variation in the relative proportion of Potash and Soda present in certain samples of Barley grown in plots of ground artificially impregnated with one or other of these Alkalies.*

BY CHARLES DAUBENY, M.D., F.R.S.,

PRESIDENT OF THE CHEMICAL SOCIETY OF LONDON.

Although the necessity for a due supply of earthy and alkaline matters to the growing vegetable may be at present regarded as indisputable, a good deal still remains to be done before we can pretend to lay down, with any degree of certainty, the extent to which any one of those ingredients, commonly present in a particular plant, may be replaced by others, without affecting its health or development.

Saussure,* indeed, had long ago ascertained, that a tree varied

* Recherches sur la végétation, 1804.

in its mineral constitution according to the nature of the soil in which it had grown; a fir, for instance, taken from a felspathic rock, being found by him to contain much potash, but no magnesia; whilst the same from a dolomitic rock was charged with magnesia, but exhibited a proportionate deficiency in alkali. Berthier,* also, had afterwards confirmed this inference by his analysis of two samples of oak timber, the one obtained from Norway, the other from Allevard, in Dauphiny, as the proportion of soda and of potash was found by him greater in the former instance than in the latter.

The independent results of these trustworthy chemists, Liebig† has endeavoured to bring under the operation of a general law, which he has himself suggested, in showing that the sum of the oxygen present in all the samples of timber analyzed, whether by Saussure or by Berthier, was uniformly the same, however much in relative amount the bases themselves might vary. This remarkable observation would certainly seem to favour the idea that, provided there be bases present in the soil sufficient for neutralizing the organic or mineral acids generated or secreted by the growing vegetable, the nature of the former was comparatively unimportant; and thus might lead us to conjecture, that isomorphous bodies, at least, which replace each other in the structure of a mineral, might do the same also in the organization of a plant.

Amongst other facts tending to the same conclusion, may be cited the analyses made some years ago by Will and Fresenius, of barley grown in the interior of Germany, and in the more maritime districts of the Netherlands, as the former was found to contain a smaller proportion of soda in comparison with the potash present, than the latter.

But before we allow ourselves to push our inferences beyond the point to which the above facts strictly warrant us in proceeding, let us consider, for a moment, the arguments that may be adduced on the opposite side, as tending to show, that a certain definite mineral composition is to be ascribed to each particular plant, and probably even to every one of the several organs of which it is made up. If the nature of the mineral ingredients present in a plant were a matter of indifference, provided only the neutralizing power possessed by them were sufficient for the purpose of enabling them to combine with the acids present; or even if, without proceeding to this extent, we suppose one alkali capable in general of supplying

* Ann. Ch. Phys. [2], LXXXII.

† Chemistry in its application to agriculture, &c.

the place of another, or an alkaline earth of being substituted for an alkali, what then is the end of that remarkable power of selection which all plants possess, and which is so remarkably evinced by those of marine origin, in their assimilation, not only of iodine, but also of potash, from a sea containing both in infinitesimal proportions only. The case of the Algæ, indeed, is only an extreme example of a generally pervading law; for it is sufficient to cast a glance over any series of vegetable analyses, as, for instance, the tabular view given by Dr. Karl Bischof in a late number of the "*Journal für praktische Chemie*,"* of the composition of various plants, to be convinced, that they in general absorb potash in preference to, and even to the exclusion of, soda, without reference to the comparative abundance of the two alkalies in the soil.

Dr. Bischof shows, that out of a series of 200 ash analyses of land plants, or of particular portions of them, there are more than $\frac{6}{7}$ ths in which the proportion of potash was estimated to exceed that of soda, and more than $\frac{1}{2}$ th in which potash alone was found, these latter analyses moreover being the most recent, and probably, therefore, the most trustworthy. On the other hand, there is not a single plant known in which soda alone occurs, and only a few, excepting those belonging to the class of marine algæ, in which its amount exceeds that of potash. Bischof also assigns reasons for supposing that the proportion of soda in the ashes may often have been over-estimated. It seems, moreover, difficult to understand, why, if soda can take the place of potash, and lime or magnesia of either, the same should not be the case with strontia; and yet I found several years ago,† that when a plant had been watered with a solution containing that earth, so minute a trace of it was found in its ashes, that it became impossible to suppose the principle in question to have entered into the composition of its tissue. Lastly, with reference to the results obtained by Will and Fresenius, I may be permitted perhaps to set against them, some made a few years ago in my own laboratory, which tended to show, that barley possessed the same mineral composition, so far as its alkalies were concerned, whether it had been grown in the east or west coasts of England, or in the more central district of Oxfordshire.‡

Deeming, therefore, the subject to be one open to further investigation, I was induced last summer to institute a few experiments;

* Vol. XLVII.

† *Linnean Trans.* 1833.

‡ Bakerian Lecture on the rotation of crops, in the *Ph. Trans.* for 1845.

the results of which I will next submit, as introductory to a statement of certain views respecting the mode in which the two alkalies come to be formed in the ashes of a plant, and the functions severally discharged by them in their living organisation, which I am desirous of laying before this Society.

For the purpose of ascertaining how far the alkaline constitution of a crop of barley might be modified by a difference in the quality of the soil in which it was grown, I selected in the same part of the Oxford Botanic Garden, seven plots of ground, of equal size, and as nearly as possible similar in point of quality, exposure, &c. Two of these plots were manured with a pretty strong dressing of subcarbonate of potash; two with an equivalent amount of subcarbonate of soda; two with common salt, in quantity sufficient to supply the same proportion of soda as the last; whilst the seventh was left without any application at all. The size of the plots was such, that the quantity of potash added would be equivalent to about ten bushels of common salt to the acre, and to corresponding quantities of carbonate of soda, and of carbonate of potash to the same surface of soil.*

In order to prevent these saline matters from being too speedily washed away by rain, I had previously dissolved them in water, and had mixed each of the several solutions with a bulk of stiff clay large enough to absorb the whole of the liquid. The mixture was then exposed to the sun and air, in order that the salts might become dry, and be thoroughly incorporated with the mass; after which the whole was thrown upon the plots intended for their reception, and mixed up intimately with the soil down to the depth of two feet from its surface.

An equal amount of barley was then sown in each of the said plots, and the crop obtained separately dried and weighed, the straw and grain having been kept distinct. A portion of each having been then incinerated, the soluble portion of the ash was taken up by water, after which everything, except the alkaline salts, was removed by the methods usually employed for that purpose. An aliquot portion of the alkaline residuum was in each case converted into chloride, and the potash separated from the soda-salt by means of the chloride of platinum.

* The quantities being respectively :

7	lbs. of pearl-ash,
20	„ of subcarbonate of soda in crystals,
9	„ of common salt to each plot,

these numbers representing equivalent amounts of the two alkalies.

The following were the results obtained by this method :

PLOTS :					
Manured with :	yielded :				
	altogether.	of :	in 100 parts of the alkaline residuum.		
Carbonate of potash . {	average of the two crops } 71½ lbs.	viz. { grain 13½ lbs.	Potash.	Soda.	
Carbonate of soda . {	} 71 "	{ straw 58 "	84·50	15·50	
Chloride of sodium . {	} 78 "	{ grain 13½ "	79·50	20·50	
		{ straw 57½ "	76·50	23·50	
		{ grain 14½ "	72·75	27·25	
		{ straw 63¾ "	76·50	23·50	
Unmanured.	produce of the bed . . . } 63 "	viz. { grain 11 "	82·50	17·50	
		{ straw 52 "	79·50	20·50	

The difference between the amount of produce, in the bed left unmanured, and in the rest, sufficiently attests the benefit that had been derived from every one of the saline matters added, and that nearly in an equal ratio from each of them ; whilst the larger amount of soda present in the crops which had been dressed with carbonate of soda and with chloride of sodium, might seem to indicate, that this alkaline principle had, to a certain extent, taken the place of the potash, in consequence of its being present in the soil in a larger proportion here than in the other plots.

But a little further consideration may perhaps suggest a different mode of explaining the facts in question. It must be recollected in the first place, that the roots of plants suck up indiscriminately from the soil every kind of matter presented to them, whether it be poisonous to them or nutritious, as was long ago ascertained to be the case by Saussure.

There must, therefore, be circulating through the system of a plant, during all the stages of its growth, a certain amount of every species of saline matter which happens to lie in contact with its roots, of which, although only that which is capable of being assimilated by its organs actually constitutes a part of its substance, the remainder is nevertheless detained within the vegetable tissue for a certain time, and cannot be separated from it by any known mechanical process.

When therefore we dry a plant, and reduce it to ashes, its residuum after incineration will contain, not only the alkaline matter which actually entered into the composition of the organs themselves, but likewise that circulating at the time through its tissue. The former

indeed, may be assumed to bear a constant relation to the volatilizable ingredients associated with it, but the latter will necessarily vary according to the nature of the saline impregnation belonging to the water which bathes its roots.

Thus, from the soil to which nothing had been added, a certain amount of soda as well as of potash would seem to have been extracted by the barley grown in it, since both alkalies made their appearance in the portions incinerated. This, however, is easily explained, inasmuch as, by a previous analysis, both soda and potash had been found to exist as original constituents of the soil. It is probable, however, that a good deal of the estimated quantity of each did not actually enter into the constitution of the organs, but had been merely arrested in its progress through the plant, so as to be present in it at the moment when the crop was cut down.

From the addition of carbonate of potash to the soil, only a small increase to the percentage of potash in the plant itself appears to have resulted; but it must be recollected, that the quantity of potash present in the ground was distributed over a greater amount of crop, as the produce of the beds rose, in consequence of this addition, from 63 to 71½ lbs.

By the dressing of carbonate of soda given to the third set of beds, the percentage of soda was augmented in a still higher ratio, because the increase of crop which followed did not in the same degree augment the consumption of soda by the plant, as this alkali enters less abundantly into its actual organisation. A larger proportion of it, therefore, would remain in the juices circulating through the vegetable tissue, and would therefore add to the apparent amount of soda in the crop when examined.

The same explanation may apply to the increase of the same alkali which took place in the crop that had been manured with common salt; this, however, would appear to exist in the plant as common salt, since, judging from the results of the analyses given in my Bakerian Lecture,* the salt in question enters, as such, into the tissue of a plant without undergoing decomposition.

I may perhaps elucidate my meaning by the following hypothetical statement, in which the numbers given must be understood to be quite arbitrary, and intended merely for the purpose of illustration.

Confining ourselves to the grain of the barley experimented upon, let us assume the normal quantity of potash and soda present in it to stand to each other in the relation of 74 of the former to 9 of the latter.

* Phil. Trans. for 1845.

Then, in the unmanured crop :

Normal quantity being	Potash	74.0	Soda	9.0
There will have been circu-				
lating through the crop				
when cut	„	8.5	„	8.5 or 50 to 50.
		82.5		17.5

In crops manured with carbonate of potash :

Normal quantity	Potash	74.0	Soda	9.0
Circulating through the crop	„	10.5	„	6.5 or 67 to 33.
		84.5		15.5

In the crops manured with carbonate of soda and chloride of sodium :

Normal quantity	Potash	74.0	Soda	9.0
Circulating through the crop	„	2.5	„	14.5 or 15 to 85.
		76.5		23.5

The above explanation may perhaps be open to objection ; but I conceive it to be at least encumbered with fewer difficulties than would attend the notion of an actual substitution of soda for potash taking place within the organism of a plant ; for in that case we must suppose, that although a certain number of the atoms of the one alkali may be replaced by the other, no such change can take place with regard to the greater part of those present ; for were the latter possible, that is, were the whole, or the greater part of the atoms of potash capable of being replaced by soda, not only would there have been a much greater difference in the constitution of barley grown in soils so largely impregnated, as mine were, with salts of soda, in comparison with the same charged with those of potash ; but we should also be at a loss to explain the absence of a larger proportion of soda-salts in those samples of barley which I had obtained from the neighbourhood of the sea, than existed in others taken from inland situations.

In the experiments above detailed, the utmost increase of soda in the crop, caused by so liberal an application of soda-salts to the soil, did not exceed 8 per cent of the whole ; or in other words, if we adopt the hypothesis of substitution, only 1 atom in 12 of the potash actually present admitted of being replaced by soda : nor does it

appear, that the largest disproportion between the quantity of the two alkalies brought into contact with the plant can materially affect this limitation; for otherwise, marine algæ, which are nourished by a fluid in which the potash stands in the smallest possible relation to the soda, could scarcely contain so large an amount of potash as is frequently found to exist in them. And yet, although we must, in adopting this hypothesis, assume certain limits to exist, beyond which the usual constitution of a plant does not admit of change even by the most liberal supply of soda, a large excess of this latter alkali must be supposed necessary, in order that it should replace the potash in any degree at all; inasmuch as we find no extraordinary amount of the mineral alkali in barley grown near the sea, where soda-salts must be more abundant than they are inland.

These considerations would lead me to imagine, that even in marine plants, a portion of that large quantity of soda, which is detected in their ashes, may be derived from the juices circulating through their cellular structure, and does not enter into their actual organisation; so that even in them, perhaps, potash may turn out to be the alkali which plays the principal part in building up the living fabric of the plant. I am by no means inclined, however, to limit the uses of the alkaline matter which is constantly contained in the sap, to the one end of supplying a plant with the potash and soda, which it requires, for the formation of its different organs, and for that of its characteristic secretions; since Liebig himself has pointed out another function which both alkalies are equally fitted to discharge, namely, the fixation of carbonic acid, through which, owing to the consequent diminution of oxygen, sundry other organic acids, such as the tartaric, the oxalic, the malic, &c. may be formed.

It is not my intention, however, to pursue this fertile subject on the present occasion; in conclusion, therefore, I will only remark, that I am fully aware of the scantiness of the data contributed by myself in this paper towards the elucidation of the question discussed in it; and that I should have been reluctant to occupy the time of this Society by bringing them forward, had I not hoped that they might be the means of stimulating others of our members, who have more leisure than myself, for such investigations, to undertake a larger and more precise train of experiments, calculated to determine the still questionable point, as to the power residing in plants to substitute one mineral ingredient for another, in the construction of their respective organs, or in the elaboration of the peculiar secretions which they contain.

IV.—*On the Compounds of Cotton with the Alkalies.*

BY J. H. GLADSTONE, PH. D.

THE beautiful effects produced by Mr. Mercer through treating cotton with a cold solution of caustic soda, are well known not only to the scientific world, but, through the medium of the Great Exhibition, to the public in general. Yet I believe the chemical compound itself has not hitherto been investigated.

This gentleman found that when cotton, or a cotton fabric is immersed in a very strong alkaline ley in the cold, a certain combination is effected. This "sodaed" cotton parts with all its alkali when washed with pure water, and the "mercerized" cotton thus produced, is not only much contracted, so that coarse fabrics have assumed the appearance of fine ones, but when dyed it displays colours of more than ordinary brilliancy.

It is evident that, by the process described above, the combination of soda and lignine is not obtained in a state fit for analysis. As the fabric issues from the alkaline ley, there adheres to it an excess of soda, and the moment it is touched by water its integrity is destroyed. It became a desideratum then to find a solvent capable of removing the uncombined alkali whilst it left the compound unimpaired. Alcohol suggested itself to my mind as likely to possess the requisite quality, especially as it might be employed in an anhydrous condition.

As preliminary experiments, two portions of pure cotton were taken, each weighing 20 grs. when thoroughly dried. The one was steeped in cold caustic soda, so dilute as not to produce Mr. Mercer's reaction, the other in a strong solution of soda. They were both soaked repeatedly in successive portions of absolute alcohol, and subsequently dried in vacuo over sulphuric acid. In Exp. I. the cotton proved to be of the original weight, and did not retain any soda; in Exp. II. the cotton had increased to 24.4 grs., and contained an amount of soda, which, when dissolved out by water, neutralized by sulphuric acid, and evaporated in a platinum dish (excess of sulphuric acid in combination being removed as usual by small pieces of carbonate of ammonia), gave 4.8 grs. of sulphate = 2.1 grs. of absolute soda. From the first experiment, the conclusion may be drawn that absolute alcohol is capable of removing from cotton any portions of uncombined soda; and from the second it may be inferred that such alcohol does not decompose the compound of soda and cotton.

Having thus obtained a method, I performed a series of more exact experiments. A solution of soda of sp. gr. 1.124 was found capable of combining with cotton, though it did not produce much shrinking. It was made use of in preference to a stronger solution, as it left less alkali adhering to the fibre to be afterwards washed out with alcohol.

Exp. III. 20 grs. of cotton steeped for an hour in the alkaline ley, washed repeatedly with absolute alcohol, and thoroughly dried in vacuo, had increased to 21.97 grs., and furnished 2.70 grs. of sulphate of soda.

Exp. IV. The cotton regained from Exp. II., similarly treated, showed an increase in weight to 21.09 grs., and yielded 2.71 grs. of sulphate of soda.

Exp. V. 20 grs. of cotton were treated in precisely the same manner, but as the difficulty of washing out the uncombined soda consumed much absolute alcohol, ordinary rectified spirits was employed instead. The soda compound weighed 21.28 grs., and yielded 2.05 grs. of sulphate of soda.

Exp. VI. 20 grs. of cotton similarly treated, were washed with hot alcohol of sp. gr. 825. The dried compound weighed 22.20 grs., and yielded 3.12 grs. of sulphate. This is a large amount, and indicates that alcohol of this strength may safely be employed to wash the compound.

Exp. VII. Lest it might be contended that the alcohol did not remove from the woody fibre certain impurities, which might be present in an aqueous solution of soda, 20 grs. of cotton were steeped in a clear but saturated alcoholic solution of the alkali. Little if any shrinking took place, but there was a certain amount of combination, for the cotton well washed with spirits of sp. gr. 825 and dried, weighed 21.01 grs., and afforded 1.41 grs. of sulphate of soda.

As yet the results are very discordant, as will be apparent from the annexed table, nor does the combined soda in any instance stand in a definite atomic ratio to the lignin :

Exp.	Ratio between original and soda-ed cotton	and combined soda.
III.	100 : 109.85	: 5.91
IV.	100 : 105.45*	: 5.94
V.	100 : 106.4	: 4.49
VI.	100 : 111.0	: 6.83
VII.	100 : 105.05	: 3.08

* This number is reckoned as obtained from 20 grs.; but it is in all probability too low, since the whole amount of cotton, as will be afterwards explained, is never recovered from the mercerizing process.

From this we must conclude either that woody fibre has a great affinity for caustic soda at a low temperature, but does not form any definite chemical compound with it; or else that the cotton in the forementioned experiments had not been thoroughly saturated with the alkali. As this might depend upon the strength of the alkaline ley in which the immersion was made, a solution of soda of sp. gr. 1342 was employed, and gave much more satisfactory results.

Exp. VIII. 20 grs. of cotton steeped in soda-solution of the above-mentioned specific gravity, and washed with successive portions of hot alcohol of sp. gr. 825, until when dried it ceased to lose weight, was found to have increased to 22.64 grs., and yielded 4.25 grs. of sulphate of soda.

Exp. IX. 20 grs. of previously mercerized cotton, similarly treated, showed an increase of weight to 23.21 grs., and yielded 4.70 grs. of sulphate.

Exp. X. A piece of calico 4 in. $\times$ 4, and weighing, when thoroughly dried, 18.65 grs., was subjected to the action of soda. From a solution of sp. gr. 1124 it absorbed an amount of soda equivalent to 2.00 grs. of sulphate; that is, as 100 : 4.70 combined soda. Washed with water, dried, again immersed in alkaline ley, but of sp. gr. 1342, washed with hot alcohol of sp. gr. 825, and dried in vacuo, it weighed 21.84 grs., and yielded 4.40 grs. of sulphate of soda. The immersion in soda only lasted 10 minutes. The piece of calico had contracted to the measure of 3.3 in. $\times$ 3.3.

Exp. XI. In order to ascertain whether the fibre was capable of combining with a still larger proportion of soda, either by employing a stronger alkaline ley, or by exposing it to the action for a longer period, a piece of calico weighing 18.32 grs. was immersed for 17 hours in a solution of caustic soda so strong as to be syrupy, in a vessel protected from the atmosphere. Having been washed and dried as usual, it weighed 21.04 grs., and yielded 3.78 grs. of sulphate of soda. This, instead of being a larger amount of soda than in the three previous instances, is a trifle smaller. There was the same amount of contraction.

Exp. XII. was intended as one in which every precaution should be taken to insure the definite character of the compound examined. A piece of fine calico of about 90 strands to the inch, weighing 14.67 grs., and measuring 3 in. $\times$ 3, was steeped in cold caustic soda in a close vessel for 30 minutes. It was then removed, pressed between folds of cloth, and washed with absolute alcohol also in a vessel protected from the air, until it ceased to lose weight when dried. Dried

in vacuo it weighed 17·17 grs., and it afforded 3·15 grs. of sulphate of soda.

The results of these five experiments may be thus tabulated :

Exp.	Ratio between original and soda-ed cotton	and combined soda.
VIII.	100 : 113·2	: 9·31
„ IX.	100 : 116·05	: 10·30
„ X.	100 : 111·2	: 10·34
„ XI.	100 : 114·8	: 9·07
„ XII.	100 : 117·05	: 9·41

It will be at once evident that there is a wide discrepancy between the numbers in the first column, but the second column presents considerable accordance; and, if we take the amount of soda in the experiment most to be relied on—No. XII., namely, 9·41 per cent, or the average of the whole five determinations,—namely, 9·68 per cent, we find it almost exactly coinciding with the amount that should be obtained, supposing one atom of soda to combine with one atom of lignine— $C_{24}H_{20}O_{20}$ —namely, 9·65.

$$324 : 31·3 :: 100 : 9·65.$$

The mode of production of this substance might lead us to imagine that it was a substitution product of $C_{24}H_{20}O_{20}$, in which one equivalent of sodium replaced one equivalent of hydrogen; but, as the weight of the dried substance never fell short of the united weights of the cotton and the soda taken up, it must rather be considered as a compound of the two. The difference of its state of hydration clearly gives rise to the differences observable in the first column of the tables. In some instances (as Exp. X.) the soda appears to carry along with it little or no water, in other instances (as Exp. XII.) as large a quantity as 3 equivalents; and this combined water will not separate in vacuo at ordinary temperatures. The compound is also very hygroscopic, absorbing from moist air, in one observed instance, as much as 5·39 grs. of water for 23·21 grs. of “soda-ed” cotton, which however it parted with again in vacuo. When neutralizing with sulphuric acid the soda washed out from the cotton, I had frequently observed that there was no effervescence: this induced me to try whether the “soda-ed” cotton really did not absorb carbonic acid. Upon exposing a portion to an atmosphere of this gas, I found the alkali was converted into carbonate; and 20 grs. of cotton, which proved to be combined with 2·06 grs. of soda, weighed when dried in vacuo 23·71 grs. Little or no water could have been retained by the

substance, for the weight of the cotton, plus that of the alkali considered as carbonate, would be 23·51 grs. There is a remarkable circumstance attending this compound in its relation to heat: it becomes scorched at a far lower temperature than the original cotton.

That the combination of the soda with the cotton has effected a permanent change upon it is certain; when regained it is contracted, and takes dyes better; but the question arises: Is this merely a physical alteration, or has a real chemical change of the lignina taken place? I am inclined to view the "mercerized" cotton as chemically identical with the original substance. In the first place, it is of the same ultimate composition. It is true, the cotton regained never absolutely equalled the original in weight; but it was always observed that the fibre lost some flocculent portions during the steeping and the washing processes, enough to account for the 1 or 1·5 per cent deficiency which usually occurred. The removal of only one equivalent of water would have occasioned a decrease of 2·78 per cent. Again, the mercerized cotton can be recombined with soda, causing even some additional shrinking by the process. Mixed nitric and sulphuric acids convert it into gun-cotton; it is acted upon by oil of vitriol just as ordinary lignine; and it is similarly hygroscopic.

The change that takes place in the physical condition of the cotton is best observed under the microscope. The fibres in their ordinary state appear as flattened twisted ribands; but the moment they are touched by the alkaline ley they untwist themselves, and contract in length, as they swell out, assuming a rounded solid form; and this circular appearance they retain after the soda is removed by water. Thus the shrinking is explained, and I think also the superior character of the colours which mercerized cotton is capable of exhibiting. For the substance of the fibre itself is of a porous nature, and will of course absorb a larger quantity of the dye when expanded, than when compressed into a flat twisted band, and as this takes place in the same space, a greater *intensity* of colour must be the result.

From these observations it appears that lignine is capable of forming a combination with soda, the proportion of the alkali varying with the strength of the solution employed, but in no instance exceeding one atom, and that this compound is decomposed by water, being resolved into its original compounds.

In order to ascertain whether a similar potash compound existed, a piece of fine calico, measuring 3 in. $\times$ 3, and weighing 14·50 grs., was immersed for thirty minutes in as strong a solution of potash as

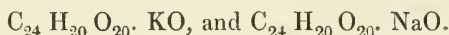
could be obtained limpid. It was washed with alcohol of sp. gr. 825, and dried and decomposed as usual. It shrank to the dimensions of 2·7 in. $\times$ 2·7. When combined with potash it weighed 17·14 grs., and it yielded 3·83 grs. of sulphate of potash.

	Ratio between	
	original and combined cotton	and potash.
Exp. XIII. . . .	100 : 118·2	: 14·27

This shows that there was one equivalent of potash taken up by the cotton, the compound being $C_{24}H_{20}O_{20} + KO$.

$$324 : 47·3 :: 100 : 14·59.$$

These compounds of the alkalis with lignine are clearly analogous to their known compounds with sugar. Brendecke and others have shown that both cane- and grape-sugar will combine with potash and soda in the proportion of 1 equivalent, $C_{24}H_{20}O_{20}$, to 1 equivalent of the alkali. Whether these compounds are decomposed by water does not appear from the recorded observations; for whether it be so or not, the same phenomena would be presented. Disregarding the varying amount of water combined with the lignine compounds, we find both them and the sugar compounds expressed by the formulæ :



V.—*On the occurrence of Capric and Caprylic acids in some Fousel oils*

BY THOMAS H. ROWNEY, F.C.S.,

ASSISTANT IN DR. ANDERSON'S LABORATORY, EDINBURGH.

In a paper read before the Royal Society of Edinburgh and published in their Transactions,* I pointed out that capric acid could be obtained from the fousel oil procured from some of the Scotch distilleries. At the same time, I mentioned that another acid was present, but in such small quantity that its constitution could not be ascertained.

The capric acid was found in the residue obtained after distilling off the amylic alcohol, and in that portion of the residue having the

* Vol. XX, Part 2nd. p. 219; abstr. Chem. Soc. Qu. J. IV. 372.

highest boiling point, viz., above 240°C . A subsequent examination of the portion boiling between 190°C . and 220°C ., enabled me to obtain a sufficient quantity of the second acid to determine its composition.

The oily residue was boiled with a strong solution of caustic potassa; dilute sulphuric acid was added to the cold alkaline solution; and the oil which rose to the surface was filtered off and washed with cold water; it was then dissolved in a solution of ammonia and precipitated by chloride of barium, and this precipitate was collected on a filter and washed with cold water. The baryta-salt was dissolved in boiling water, filtered, and allowed to crystallize; the crystals obtained were caprate of baryta. This salt was separated by filtering, and the mother-liquor was concentrated by evaporation on a water-bath. When reduced to about one-third of its bulk, it was allowed to cool, when it deposited an abundant crop of crystals; the mother liquor from these crystals gave another crop by being again concentrated. The baryta-salt was purified by re-crystallization, and an analysis made of it. The baryta was determined as carbonate, by ignition in a platinum crucible, the salt burning very readily:

I.

·2872 grms. of substance, dried at 100°C ., gave
·1340 „ „ carbonate of baryta.

II.

·3300 grms. of substance gave
·1535 „ „ carbonate of baryta.

III.

·2930 grms. of substance gave
·1360 „ „ carbonate of baryta.

IV.

·2705 grms. of substance, dried at 100°C ., and burnt with
chromate of lead, gave
·4487 „ „ carbonic acid, and
·1772 „ „ water.

V.

·2973 grms. of substance gave
·4940 „ „ carbonic acid, and
·1988 „ „ water.

	I.	II.	III.	Mean.
Ba O	36·24	36·12	36·04	36·13.
	IV.	V.		Mean.
Carbon	45·24	45·31		45·28
Hydrogen	7·28	7·42		7·35.

The numbers obtained, correspond with those for caprylate of baryta, as will be seen by comparing the theoretical numbers with those obtained by experiment.

			Mean of experiment.
C ₁₆	96	45·37	45·28
H ₁₅	15	7·09	7·35
O ₃	24	11·34	11·24
BaO	76·6	36·20	36·13
	211·6	100·00	100·00

This examination shows, that, in addition to the usual constituents of fousel-oil, viz., water, alcohol and amylic alcohol, the fousel-oil obtained from some of the Scotch distilleries, contains compounds having a higher boiling point than amylic alcohol, and that capric and caprylic acids are present in these compounds, but whether as amyl or ethyl compounds could not be ascertained, as no fixed boiling point could be obtained on distillation.

VI.—*On the oxidation of Chinese wax.*

BY NEVIL S. MASKELYNE, M.A.,

DEPUTY READER IN MINERALOGY TO THE UNIVERSITY OF OXFORD.

The experiment which I propose to describe, suggested itself in the course of an investigation commenced by me in the laboratory of Mr. Brodie in the early part of last year, but which has been interrupted by unavoidable circumstances, and only recently resumed. Without entering upon the other questions involved in that investigation, it is only necessary to state that it embraced the inquiry into the chemical nature of the substances which we know as Chinese wax and spermaceti. When isolated from certain slight impurities which it contains, Chinese wax has the formula C₁₀₈ H₁₀₈ O₄, which, by the action of hydrate of potash, may be broken up into substances with

the formulæ $C_{54} H_{56} O_2$ [cerotin] + $C_{54} H_{54} O_4$ [cerotic acid], two equivalents of water being assumed in the saponification. If instead of melting the Chinese wax with hydrate of potash with a view to saponify it, it be mixed with lime and potash, and heated gently in a large combustion tube, a change takes place in the substance, which is of a definite character, and therefore easily controlled. Hydrogen gas is evolved at the part of the tube where the heat is applied; and so soon as this evolution ceases, the coals should be removed to another part of it. The product resulting from this oxidation of the wax is, as will be seen, a salt of cerotic acid, and if the process be carefully performed, this forms a very neat, indeed the best way of procuring this wax-acid.

$5\frac{1}{2}$ oz. of potash-lime were taken to oxidize 1 oz. of Chinese wax. The resulting mass was boiled for a long time with hydrochloric acid; the wax matter thus eliminated was then frequently boiled with water, and finally dissolved in alcohol, and filtered while hot. A little undissolved substance remains on the filter, but it is only in very minute quantity. On the cooling of the alcohol, the dissolved substance forms a copious white precipitate of which the melting point is 79° — 80° C. The acid, however, is not pure; for here, as is probably also the case with spermaceti, there is present a contaminating substance in small quantity, which it is very difficult to separate completely. The mass of acid has to be dissolved and crystallized two or three times out of alcohol, and finally once or twice out of ether. The ether holds in solution the substance alluded to, which exists in very small quantity, and has a melting point at least as low as 69° . The acid, as thus obtained, is pure cerotic acid. Its melting point is 81° , 82° , and it yielded, on being analyzed, the following numbers:

I.	·2332 grms. gave	·6771 CO_2	and	·2725 HO
II.	·2110 „ „	·6118	„	·2536
III.	another preparation,			
	·2355 „ „	·6814	„	·2841

which correspond to the following per-centage of carbon and hydrogen:

	I.	II.	III.	Theory requires.
Carbon	79·19	79·07	78·90	79·02
Hydrogen	12·98	13·35	13·41	13·17
Oxygen	7·83	7·58	7·69	7·81
	100·00	100·00	100·00	100·00

The silver-salt was formed by means of an alcoholic solution of nitrate of silver, and a solution, also in alcohol, of an ammonia-salt of the acid in the presence of an excess of ammonia. It yielded the following per centage of silver :

6.10 grs.	gave	1.280 grs.	=	20.98	per cent
4.81	„	1.010	„	=	20.99 „
Theory requires				20.90	„

There can, therefore, be little question as to the character of the change thus wrought by the oxidizing action of the potash-lime. Regarding the wax as the homologue of acetic ether, the acid has its origin in two sources. On the one hand, the ether, of which cerotin is the corresponding alcohol, is oxidized into cerotic acid, while on the other hand, the anhydrous cerotic acid, which on this view is supposed to be combined with that ether, unites with the alkali, the process being divided into two parts, first, the saponification of the substance, and subsequently the oxidation of the alcohol formed from the ether by that saponification. On another view, first propounded by Mr. Lawrence Smith in relation to spermaceti, we may look upon these bodies as homologues of aldehyde, in which case the wax may be regarded as the aldehyde of cerotic acid, its formula being halved [$C_{108} H_{108} O_4 = 2 (C_{54} H_{54} O_2)$]. Regarding it in this light, the oxidation is that of the substance as a whole into cerotic acid, $C_{54} H_{54} O_2 + O_2 = C_{54} H_{54} O_4$. The present experiment does not decide between these two views. I have made some further experiments in this direction, which I hope on a future opportunity to communicate to the Society. The process I have described is important, as furnishing by far the most expeditious method we at present possess of procuring cerotic acid; for the washing out of the baryta-salt, formed in the treatment of the Chinese wax, or of the lead-salt of cerotic acid from common bees-wax, is a most tedious operation.

Spermaceti is a body precisely identical in type with Chinese wax. I have oxidized this substance also, in the expectation that the result would clear up the doubt as to the identity or otherwise of ethalic and palmitic acids. These experiments do not belong to the history of Chinese wax, and it will therefore be preferable to make them also the subject of a future communication.

On a quick approximative method of estimating minute quantities of iron by means of a Colorimeter. BY THORNTON J. HERAPATH.

The author having been much occupied with the analysis of waters containing minute quantities of iron, and finding the ordinary mode of estimation by precipitation and weighing very troublesome and inaccurate, when applied to such quantities, was led to avail himself of the following centigrade method, founded on the reaction of persalts of iron with sulphocyanide of potassium. A standard solution of perchloride of iron containing a little less than $\frac{1}{1000}$ th of a grain of metallic iron per cent, was prepared by dissolving 1 grain of iron in hydrochloric acid, with the addition of a little nitric acid, evaporating nearly to dryness, and diluting to 10,000 gr. measures with distilled water at 60° ; and from this, other standard solutions of different strengths were formed. A convenient quantity of the water, generally half a gallon, was evaporated to dryness, and the saline mass so obtained was afterwards dissolved in hydrochloric acid. The iron contained in the solution having been converted into perchloride by boiling with a few drops of nitric acid, the silica and other insoluble substances were separated by filtration, and the peroxide of iron precipitated by ammonia. This latter precipitate was collected on a filter, and well washed with water. It was then redissolved in the smallest possible quantity of hydrochloric acid, and the liquid having been introduced into a phial or tube of known capacity, was diluted with distilled water, until it reached a particular mark upon the side, corresponding to 1000 water-grain measures; care being taken of course to add previously a few drops of a solution of sulphocyanide of potassium. The depth of tint was then compared with that of the standard solutions before mentioned, contained in tubes or phials of similar diameter, in which certain known quantities of iron, ranging from the $\frac{1}{1000}$ th to the $\frac{1}{4}$ th of a grain, were contained in the same bulk of water. In order to render the comparison of tints more perfect, the tubes were placed against a sheet of white writing paper, and held between the eye and the diffused light. Operating in this way, the author was enabled to estimate the $\frac{1}{1000}$ th of a grain of iron per gallon with the greatest readiness. It was sometimes found preferable to employ but one standard solution. The proportion of iron, in the liquid tested, was then determined by measuring the volume of water that was required to lighten the tint so as to render it identical with that of the normal solution, or *vice versa*.

On Dr. Keller's supposed formation of Metacetic Acid from Flour and Leather.* BY R. W. FORSTER.

A mixture of flour with scraps of leather, carbonate of lime, and water, having been digested for three weeks at a gentle heat, the liquid was strained off, the dissolved lime-salt converted into a soda-salt, the solution concentrated by evaporation, and distilled with excess of sulphuric acid. A portion of the acid distillate was then neutralized with carbonate of soda, the remainder added to it, and the whole distilled. According to Keller, butyric ether should distil over, acetate and metacetate of soda remaining in the retort. The distillate obtained by Mr. Forster, however, had an odour not at all resembling that of butyric ether; and the dry residue, when distilled with sulphuric acid, yielded a distillate which had not the odour of either acetic or metacetic acid, and gave no odour of acetic ether when heated with alcohol and sulphuric acid. The liquid also yielded a baryta-salt containing 65.5 per cent (mean) of baryta, a quantity differing by $1\frac{1}{2}$ per cent from 67.4, the amount required by the formate; the deficiency was probably due to slight impurities. Acetate of baryta contains 60, and metacetate of baryta 54.06 per cent of the base. Moreover, the solution of the baryta-salt rapidly reduced nitrate of silver. The principal constituent of the distillate appears therefore to be *formic acid*.

* See this Journal, Vol. III, p. 190.

PROCEEDINGS
AT THE
MEETINGS OF THE CHEMICAL SOCIETY.

January 19, 1852.

PROFESSOR DAUBENY, President, in the Chair.

The following donations were announced :

"Berattelse om Framstegen i Fysik," 1849: af E. Edlund.

"Ofversigt af Kongl. Vetenskaps-Akademiens Förhandlingar, 1850
from the Royal Stockholm Academy.

"Denkschriften der Kaiserlichen Akademie der Wissenschaften:"
Zweiter Band.

"Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften,"
Band VI. Heft I—V: from the Imperial Academy of Vienna.

"Proceedings of the Glasgow Philosophical Society," Vol. III.
No. 3: from the Society.

"Pharmaceutical Journal," Vol. II, No. 7: from the Editor.

"Journal of the Franklin Institute," Vol. XXII, No. 2: from the
Institute.

"The Literary Gazette," Nos. 1823—1826: from the Publishers.

"Prideaux's Scale of Equivalents:" from Mr. Whipple.

The following papers were read :

1. "On the Analysis of the Water supplied by the Bristol Water-
works Company:" by Thornton J. Herapath.

2. "On a quick approximative Method of Estimating minute
quantities of Iron by means of a Colorimeter:" by the same.

3. "On the Decomposition of Citrate of Lime in contact with
Putrefying Curd:" by Henry How.

Dr. Hofmann made a verbal communication on Liebig's new method of estimating the quantity of urea contained in urine. He stated that various methods had previously been recommended for estimating urea, among others, that of converting the urea into carbonate of ammonia, and ascertaining the quantity of nitrogen. This method, as well as some others, required delicate and careful manipulation; others again have been proved to furnish incorrect results. Professor Liebig had been often applied to by his physiological friends at Giessen, to devise some simple method of effecting this object, such as a medical man might himself readily apply; and he had succeeded in discovering a process which appeared to offer the means of estimating urea with great facility. It consists in treating the urine under examination with nitrate of red oxide of mercury. Urea combines with this substance, and forms a snow-white, almost insoluble, compound, which is immediately precipitated, when urine, or a fluid containing urea, is mixed with a solution of the nitrate of mercury containing no free acid. The precipitate contains one atom of urea, one atom of nitric acid, and four atoms of red oxide of mercury. As nitric acid is set free in the process, and as this free acid prevents the further action of the nitrate, it is necessary to neutralize the liquor after each addition of nitrate, with baryta-water. Liebig has found, however, that the presence of common salt in the urine presents a difficulty in the application of the process, which he has not yet completely got over.

February 2, 1852.

DR. LYON PLAYFAIR, Vice-President, in the Chair.

The following donations were announced:

"Smithsonian Contributions to Knowledge," Vol. II.

"Appendix I. to Vol. III. of the Smithsonian Contributions to Knowledge, containing an Ephemeris of the planet Neptune:" by Sears C. Walker.

"Report to the Smithsonian Institution on the History of the Discovery of Neptune:" by B. A. Gould, Jun.

"Fourth Annual Report of the Board of Regents of the Smithsonian Institution for 1849."

"Notices of Public Libraries in the United States of America:" by Charles C. Jowett: from the Smithsonian Institution.

"Reports from the Secretary of the Treasury, of scientific investigations relating to Sugar and Hydrometers, made under the superintendence of Professor A. D. Bache:" by Professor R. S. M'Culloch: from the Author.

"Proceedings of the American Association for the Advancement of Science," in 1850: from the Association.

"The American Journal of Science and Arts:" by Professor Silliman, No. 36, for Nov. 1851: from the Editor.

"Journal of the Franklin Institute," Vol. XXIII, Nos. 3 and 4: from the Institute.

"The Pharmaceutical Journal," Vol. III, No. 8: from the Editor.

"The Literary Gazette," No. 1827: from the Publishers.

"Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften," Band. VII, Heft 1 and 2: from the Imperial Academy of Vienna.

"Stahl's Fundamenta Chymie:" from Mr. George Whipple.

"Six Medallions of foreign Philosophers:" from Mr. D. Boru.

The following papers were read:

1. "On a New Method of obtaining Hippuric Acid in considerable quantity without Evaporation of the Urine; and on some of its products of Decomposition:" by Edward Riley, Assistant in the Museum of Practical Geology.

2. "On Populin:" by M. Rafaele Piria.

February 16, 1852.

PROFESSOR DAUBENY, President, in the Chair.

Frederic Claudet, Esq., of University College; Christopher Leefe Dresser, Esq., of Leeds; Charles B. Mansfield, B.A.; of Half-Moon Street; Joshua Hutchinson Robson, Esq., of 6, Highbury Park; and Rees Reece, Esq., of Ather Peat Works, near Dublin, were duly elected Fellows of the Society.

The President announced the names of the Vice-President and four other Members of the Council, who retire from office, and the Vice-President and four other Members of Council, together with the remaining Officers and Members of the present Council, who were proposed by the Council to be elected at the next General Meeting of the Society.

The following donations were announced :

“The American Journal of Science and Arts:” by Professor Silliman, for January 1852 : from the Editor.

“The Quarterly Journal of the Geological Society,” for February 1852 : from the Society.

“The Literary Gazette,” for January 31, and February 14: from the Publishers.

“Specimens of Zinc ores, in the natural and prepared states; Metallic Zinc, showing the hot and cold fractures; Rolled Zinc; a Mould illustrating the method of making Zinc Casts; a Cast of the Head of Sir Robert Peel:” from the Vieille Montagne Zinc Works.

“Specimens illustrating the Manufacture of Kelp and Iodine in Ireland:” from Mr. John Ward.

The following papers were read :

1. “On the Variation in the relative Proportion of Potash and Soda present in certain Samples of Barley grown in plots of ground artificially impregnated with one or other of these Alkalies:” by Dr. Daubeney, F.R.S.

2. “On the Compounds of Cotton with the Alkalies:” by J. H. Gladstone, Ph.D.

March 1, 1852.

PROFESSOR GRAHAM in the Chair.

G. B. Buckton, Esq., of Gloucester Place, Hyde Park, was duly elected a Fellow of the Society.

The following donations were announced :

“The Pharmaceutical Journal,” for March : from the Editor.

“The Literary Gazette,” for February 28: from the Publishers.

“Specimens of Hippuric Acid in different states of purification; of Benzoic Acid prepared from Hippuric Acid; and of Glycocol in the pure and impure state:” from Mr. Edward Riley.

The following papers were read :

1. “On the occurrence of Capric and Caprylic Acids in some Fousel Oils:” by T. H. Rowney.

2. “On Dr. Keller’s supposed formation of Metacetic Acid from Flour and Leather:” by R. W. Forster.

March 15, 1852.

PROFESSOR DAUBENY, President, in the Chair.

The following donations were announced :

"The Literary Gazette," for March 6th and 13th : from the publishers.

"Experimental Researches in Electricity;" Twenty-sixth series, "On Lines of Magnetic force, &c." by Michael Faraday, D.C.L., F.R.S. : from the author.

"On a Method of obtaining a perfect vacuum in the receiver of an Air-pump;" by Thomas Andrews, M.D., F.R.S. : from the author.

The following gentlemen were duly elected Fellows of the Society :

Alfred Smee, Esq., F.R.S., Finsbury Circus; Alfred Fletcher, Esq., Denmark Hill, Camberwell; James Higgin, Esq., Manchester.

The following papers were read :

1. "On the Detection of Alum in Flour, with remarks on the Preparation of Distilled Water and Pure Potash;" by J. H. Pepper.

2. "Contributions towards the History of Tannic Acid;" by Dr. Strecker.

Dr. Hofmann made some observations on Liebig's new process for estimating Urea, and described the methods which this Chemist uses for preparing his standard solution of mercury, and for estimating the amount of chloride of sodium in urine.

NOTICES
OF
PAPERS CONTAINED IN
British and Foreign Journals.

Chemical Report on the cause of the Fire in the 'Amazon.'

By Professor Graham.

February 17th, 1852.

MY LORDS,

In reply to the questions arising out of the disastrous loss of the 'Amazon' by fire which are proposed to me for a Chemical opinion, I beg to submit to your Lordships the following statements and conclusions.

The practice of mixing together the various stores of the engineer, consisting of oils, tallow, soft-soap, turpentine, cotton waste and tow, and placing them in heated store-rooms contiguous to the boilers, must be looked upon as dangerous in no ordinary degree, for several reasons. Although oil in bulk is not easily ignited, particularly when preserved in iron tanks, still when spilt upon wood or imbibed by tow and cotton waste, which expose much surface to air, the oil often oxidates and heats spontaneously, and is allowed to be one of the most frequent causes of accidental fires. The vegetable and drying oils used by painters are most liable to spontaneous ignition, but no kind of animal or vegetable oil or grease appears to be exempted from it; and instances could be given of olive-oil igniting upon sawdust; of greasy rags from butter, heaped together, taking fire within a period of twenty-four hours; of the spontaneous combustion of tape-measures, which are covered with an oil-varnish, when heaped together; and even of an oil-skin umbrella put aside in a damp state. The ignition of such materials has been often observed to be greatly favoured by a slight warmth, such as the heat of the sun. I am also informed by Mr. Braidwood, that the great proportion of fires at railway-stations have originated in the lamp-store, and that in coach-works also, when the fire can be traced, it is most frequently to the painters' department, the fire having arisen spontaneously from the ignition of oily matters. Lamp-black and ground charcoal are still more inflammable, when the smallest quan-

tity of oil obtains access to them, and should not be admitted at all among ships' stores.

The stowing metallic cans or stoneware jars of either oil or turpentine in a warm place is also attended with a danger which is less obvious, namely, the starting of the corks of the vessels, or the actual bursting of them by the great expansion of the liquid oil which is caused by heat. These liquids expand in volume so much as one upon thirty by a rise of not more than 60° of temperature, or by such a change as from the ordinary low temperature of 40° to a blood-heat; the latter temperature may easily be exceeded in an engine-room. It is remarkable that the burning a few years ago of a large steamer on the American lakes, which even surpassed in its fatality the loss of the 'Amazon,' was occasioned by the bursting, in the manner described, of a jar of turpentine placed upon deck too close to the funnel, by a party of journeymen painters who were passengers. This steamer was also on her first voyage, and being newly varnished, the flames spread over her bulwarks and extended the whole length of the vessel in a few minutes.

The bulkheads of coal-holds appear to admit of obtaining considerable security from fire by being constructed double where close to the boiler, with a sheet of air between the two partitions. The tendency of coals to spontaneous ignition is increased by a moderate heat, such as that of the engine-room, from which they would be protected by the double partition. I have obtained instances where coals took fire in a factory, on two different occasions, by being heaped for a length of time against a heated wall, of which the temperature could be supported by the hand; also of coals igniting after some days upon stone flags covering a flue, of which the temperature was not known to rise above 150° , and of coals showing indications of taking fire by being thrown in bulk over a steam pipe. These were Lancashire coals, which are highly sulphureous; but the same accident occurred with Wallsend coals, at the Chartered East Company's works in London, where the coals were twice ignited through a two-feet brick wall, of which the temperature was believed by Mr. Croll not to exceed 120° or 140° .

The surface of deal in the partition opposed to the boiler would probably be better protected from fire by impregnating the wood with a saline solution, which diminishes combustibility, such as the zinc solution of Sir W. Burnett, rather than by coating the wood on the side next the boiler with sheet iron. Indeed, this use of iron appears to introduce a new danger. The iron being a good conductor of heat, the wood below is heated nearly as much as if uncovered, and wood in contact with iron appears to be brought by repeated heating to an extraordinary degree of combustibility, and to become peculiarly liable to spontaneous ignition.

Mr. Braidwood, who has been led to that conclusion, gave an

instance of wood covered by sheet iron igniting spontaneously in a wadding manufactory. The numerous occasions, also, on which wood and paper have been ignited by Perkins' heated water-pipes, equally exemplify the dangerous consequences which may arise from moderately heated iron in long contact with combustible matter.

The most obvious precautions for guarding against the spontaneous ignition of coal stowed in ships' bunkers appear to be the taking the coal on board in as dry a condition as possible, and the turning it over, if there is room for doing so, as soon as the first symptom of heating is perceived. An obnoxious vapour is described as always preceding the breaking out of the fire, and affords warning of the danger. The ignition of Newcastle coals in store is not an unfrequent occurrence at the London gas-works. It appears always to begin at a single spot, and is met by cutting down upon and removing at once the heated coals. Long iron rods are placed upright in the coal heap, which can be pulled out, and indicate by their warmth the exact situation of the fire. Steam can be of little avail for extinguishing fire among coals in bulk; and water, although it may extinguish the fire for the time, is too apt to induce a recurrence of the evil.

For extinguishing a fire occurring in berths or cabins in the immediate vicinity of the boiler and engine-room, steam might be more advantageously applied, means of turning on the steam being provided upon the upper deck, or other distant place of safety. Steam, however, can only be said to be efficient in extinguishing flame, or a blaze from light objects, and is not to be relied upon beyond an early stage of a fire. Upon a mass of red-hot cinders the extinguishing effect of steam is insensible.

An essential condition of applying steam with success to the extinction of a fire in the engine-room, would be to prevent the rapid ingress and circulation of air at the same time, which is occasioned by the draught of the fires. This could only be done completely by valving the chimneys: for the quantity of heated air passing off by the funnels greatly exceeds in volume the steam produced by the boilers in the same time, and would rapidly convey away the steam thrown into the atmosphere of the engine-room, and prevent any possible advantage from it.

The fire in the 'Amazon' appeared to the witnesses to take its rise either in the small oil store-room situated over the boiler, or in a narrow space of from three to eleven inches in width between a bulk-head and the side of the boiler, immediately under the same store-room. No substance remarkable for spontaneous ignition, such as oiled cotton waste, was actually observed in the store-room or the space referred to. The wood itself of the bulkhead, which was within a few inches of the boiler, may have been highly dried and sensibly heated by its proximity to the latter, but is not likely to have acquired

any tendency to spontaneous ignition ; for when that property results from low heating, it is an effect of time, requiring weeks or months to develop it. The same observation applies to the decks in contact with the steam-chest which incased the base of the funnel.

Nor does it appear probable that the coals in the coal-hold of the vessel gave occasion to the fire by heating of themselves, and then burning through the wooden partition of the oil-store with which they were in contact.

These coals were from Wales, and not remarkable for this property.

They are also said to have been shipped in a dry and dusty state, and not damp, a month or two previously.

Their ignition would also have been preceded by the strong odour before referred to, which does not appear to have been remarked, although the coal-hold communicated directly with the boiler-room.

Oil was seen to drop from the floor of the store-room upon the top of the boiler, but not in greater quantity than might be accidentally spilt in drawing the oil from the tank for the use of the engineers.

A parcel of twenty-five newly-tarred coal-sacks, which had been thrown upon the boiler, also obtained, it is supposed, some of the same oil. This oil appears to be the matter most liable to the possibility of spontaneous ignition, which was noticed near the spot where the fire commenced.

But the sudden and powerful burst of flame from the store-room, which occurred at the very outset of the conflagration, suggests strongly the intervention of a *volatile* combustible, such as turpentine, although the presence of a tin can of that substance in the store-room appears to be left uncertain. It was stated to be there by two witnesses, but its presence is denied by a third witness. I find upon trial, that the vapour given off by oil of turpentine is sufficiently dense, at a temperature somewhat below 110° , to make air explosive upon the approach of a light. Any escape of turpentine from the heated store-room would therefore endanger a spread of flame, by the vapour communicating with the lamps burning at the time in the boiler-room, or even with the fire of the furnaces.

The fire appears not to have begun in the tarred sacks lying upon the boiler, although from their position, which was close to the store-room, they must have been very early involved in the conflagration, and contributed materially to its intensity. The sacks appear to have been charged each with about two pounds of tar, thus furnishing together fifty pounds of that substance, in a condition the most favourable that can be imagined for rapid combustion. The freshness of the tar and its high temperature would make it ignite by the least spark of flame, although not prone to spontaneous ignition. The burning of a group of newly-tarred cottages

in Deptford, which came under the notice of Mr. Braidwood, arose from their being set on fire by lightning, while the sun was shining upon them, and the tar liquefied by the heat.

The origin of the fire must remain, I believe, a subject of speculation and conjecture; but the extreme intensity and fearfully rapid spread of the combustion are circumstances of scarcely inferior interest, which are not involved in the same obscurity.

The timber of the bulkheads and decks near the engine-room is reported to have been of Dantzic red wood or Riga pine, and such was the character of a portion of the Amazon's timber which was supplied to me for chemical examination. The wood has had its turpentine drawn off, and differs in that respect from pitch pine. The Dantzic red wood is, in consequence, less combustible than pitch pine, but more porous and spongy. Oil-paint is absorbed, and dries more quickly upon this porous wood than upon oak and other dense woods. After their paint is well dried, pine and other woods certainly acquire from it some protection from the action of feeble and transient flames, which might kindle the naked wood. But the effect of paint, especially of fresh paint, appears to be quite the reverse, when the wood is exposed to a strong although merely passing burst of flame. The paint melts and emits an oily vapour which nourishes the flame, and soon fixes it upon the wood. There can be no doubt, therefore, that the timber of the 'Amazon' was in a more inflammable state than ship-timber usually is, from being recently painted, and also probably from its newness and comparative dryness.

But the circumstance which appears above all others to give a character to the fire in the 'Amazon' was its occurrence, not in a close hold or cabin, but in a compartment of the vessel where a vigorous circulation of air is maintained by the action of the boiler-fires and their chimneys. The air of the engine-room must be renewed under this influence every few minutes, and would be so although full of flames rising above deck through the hatchways; for a portion of these flames would always escape by the funnels, and add to their aspirating power instead of diminishing it. The combustion of bulkheads or decks once commenced in this situation would therefore be fanned into activity and powerfully supported.

The destruction of the floor of the oil store-room, and the overturning, in consequence, of the oil-tanks and combustibles into the well of the boiler-room, was probably the crisis of the fire. A mass of combustible vapour would speedily be generated, and shot about on all sides, of which the kindling power upon the new and painted timber of the bulkheads and decks would be wholly irresistible.

The burning of the 'Amazon' impresses most emphatically the dangerous and uncontrollable character of a fire arising in the engine or boiler room, where the combustion is animated by a steady and

powerful circulation of air, and the danger of collecting combustible matter together in such a place. The removal of the oil stores to a safer locality is, fortunately, generally practicable, and is the measure best calculated to prevent the recurrence of any similar catastrophe.

I have the honour to remain, &c., &c.

THOS. GRAHAM.

To the Lords of the Committee of
Privy Council for Trade.

Contributions to the knowledge of the Manufacture of Gas.

By E. Frankland, Ph.D.

(Read before the Manchester Literary and Philosophical Society, January 13, 1852.)

(ABSTRACTED BY THE AUTHOR.)

The constituents of purified gas, as used for illuminating purposes, are hydrogen, light carburetted hydrogen, carbonic oxide, olefiant and other gases having the general formula $C_n H_n$, the vapours of hydrocarbons of the form $C_n H_{n-6}$, and other hydrocarbons, the formulæ of which are unknown; in addition to these, coal-gas usually contains small quantities of nitrogen, oxygen, and bisulphide of carbon vapour; but these, for our present purpose, may be entirely disregarded.

It has always been asserted, that hydrogen and carbonic oxide possess no illuminating power, and that the light emitted by coal-gas is due to light carburetted hydrogen, olefiant gas, and other hydrocarbons; I hope, however, to prove, by the experiments detailed below, that light carburetted hydrogen is, for all practical purposes, also entirely devoid of illuminating power; and that therefore the whole of the light giving effect is due to the olefiant gas and hydrocarbons. This is an important point, as we shall find that it much simplifies the estimation of the illuminating power of any gas, and teaches us that the nature of the combustible diluents of the olefiant gas and hydrocarbons has no effect whatever upon the quantity of light emitted by the mixture.

The constituents of coal-gas may therefore be divided into two classes, viz., illuminating and non-illuminating constituents. To the first will belong olefiant gas and the other hydrocarbons above-mentioned; and to the second, hydrogen, light carburetted hydrogen, and carbonic oxide. To the first class alone the illuminating power of the gas is due; but one member at least of the second class is also indispensable as a diluent, without which we should find great difficulty in consuming the hydrocarbons without the production of much smoke. The members of the first class are all decomposed at a white heat instantaneously, at a red heat more slowly, depositing the whole, or the greater part of their carbon in the form of very fine particles, which become so many centres for the radiation of light in a

gas flame; and the greater the number of particles existing in a flame at the same time, the greater will be the light emitted by that flame. It is therefore evident, that the value of these hydrocarbons for the production of light, depends directly upon the quantity of carbon contained in a given volume, and is altogether independent of the hydrogen with which this carbon is combined; consequently, the densest or most easily condensible of these gases and vapours of the first class are those which possess the highest illuminating power. All the compounds belonging to this class are, as before stated, decomposed more or less rapidly at a red heat; in the ordinary process of gas-making, the interior walls of the retorts soon become coated with a stratum of carbon derived from this source. Now the extent of this decomposition must depend, first upon the length of time during which they are exposed to the heated materials, and secondly upon the number of particles which are in contact with the red-hot surface; consequently, it will be diminished, first, by removing the gases rapidly from the retort, and secondly, by the mixture of the illuminating constituents with the non-illuminating ones: for it is evident, that the number of particles of olefiant gas in contact with a given surface, would only be half so great if this gas were diluted with an equal volume of hydrogen, as it would be without such an admixture. Besides the use of the second class, or non-illuminating gases, which has been already stated, they are of value as forming a medium for the solution of the vapours of such hydrocarbons as exist in the liquid or even solid state, at the ordinary temperature of the atmosphere; and they thus enable us to convert an additional quantity of illuminating materials into the gaseous form, which they retain permanently unless the temperature fall below the point of saturation. The gain in illuminating power which is thus obtained, will be perhaps better seen from the following example. If 100 cub. in. of olefiant gas, being allowed to saturate itself with the vapour of a volatile hydrocarbon containing three times the amount of carbon in a given volume of its vapour as that contained in an equal volume of olefiant gas, took up, or dissolved in this way 3 cub. in. of hydrocarbon vapour, then, if we express the value in illuminating power of 1 cub. in. of olefiant gas as unity, the illuminating power of the 103 cub. in. of the mixture of olefiant gas and hydrocarbon vapour will be 109; now, if we mix these 103 cub. in. with 100 cub. in. of hydrogen, the mixture will be able to take up an additional 3 cub. in. of the hydrocarbon vapour, and the illuminating power of the 206 cub. in. will then become 118. Thus the hydrogen produces a gain in illuminating power equal to 9 cub. in. of olefiant gas, or nearly 4.5 per cent upon the total volume of mixed gases. When we consider that coal-naphtha contains hydrocarbons of great volatility, and which are no doubt the surplus remaining after the saturation of the gas from which

they have condensed, the importance of this function of the non-illuminating class of combustible gases will be sufficiently evident. I may here remark, that incombustible gases could not be employed for this purpose, since their cooling influence upon the flame during the subsequent burning of the gas would diminish the light to a far greater extent than the hydrocarbon vapour could increase it. It is evident, that all the three non-illuminating gases forming the second class, would perform both the offices I have assigned to them equally well; and therefore we have as yet seen no reason for giving our preference in favour of any one of these diluents. If, however, we study their behaviour during combustion, we shall find, that where the gas is to be used for illuminating purposes, hydrogen has qualities which give it a very decided preference over the other two. When gas is used for lighting the interior of public buildings and private houses, it is very desirable that it should deteriorate the air as little as practicable, or in other words, it should consume as small a quantity of oxygen, and generate as little carbonic acid as possible; the oppressive heat which is often felt in apartments lighted with gas also exemplifies the great advantage of its generating a minimum amount of heat.

1 cub. ft. of light carburetted hydrogen at 60° F., and 30 in. Bar., consumes 2 cub. ft. of oxygen during its combustion, and generates 1 cub. ft. of carbonic acid, yielding a quantity of heat capable of heating 5 lbs. 14 oz. water from 32° to 212° .

1 cub. ft. of carbonic oxide consumes $\frac{1}{2}$ a cub. ft. of oxygen, generates 1 cub. ft. of carbonic acid, and affords heat capable of raising the temperature of 1 lb. 14 oz. of water from 32° to 212° .

1 cub. ft. of hydrogen consumes $\frac{1}{2}$ a cub. ft. of oxygen, generates no carbonic acid, and yields heat capable of raising the temperature of only 1 lb. 13 oz. water from 32° to 212° .

Thus, light carburetted hydrogen is very objectionable as a diluent, not only on account of the carbonic acid which it generates, and the large quantity of oxygen it consumes, but also by reason of the very great amount of heat, which in relation to its volume it evolves on combustion, the absolute thermal effect being more than three times as great as that of either of the other gases. The quantity of heat evolved by the combustion of equal volumes of carbonic oxide and hydrogen is nearly, and the amount of oxygen consumed, quite the same, but the quantity of carbonic acid evolved by the first gives a decided preference to hydrogen as the best diluent.

The same comparison also shows, that where the gas is to be used for heating purposes, and the products of combustion are carried away, light carburetted hydrogen is by far the best diluent.

The experiments of Dulong on the absolute thermal effect of

hydrogen, light carburetted hydrogen, and carbonic oxide are taken as the basis of the foregoing calculations.

These remarks indicate the objects that should be chiefly regarded in the generating department of the manufacture of gas for illuminating purposes : these are

1. The formation of a due proportion of illuminating and non-illuminating constituents, so that on the one hand, the combustion of the gas shall be perfect, and without the production of smoke or unpleasant odour, and on the other, the volume of gas required to produce a certain amount of light shall not be too great.

2. The extraction of the largest possible amount of gaseous illuminating compounds from a given weight of material.

3. The presence of the largest possible proportion of hydrogen amongst the non-illuminating constituents, to the exclusion of light carburetted hydrogen and carbonic oxide, so as to produce the least amount of atmospheric deterioration in the apartments in which the gas is consumed.

I have not introduced these preliminary observations to show the inductive reasoning by which the process of gas-making described below was arrived at, for, I believe that, so far as these considerations are concerned, that process was accidentally adopted ; but I bring them forward to illustrate and explain the principles involved in it, and also to show that a close study of the chemistry of gas-manufacture would have led to the discovery of this more philosophical method of gas-generation long ago.

Various attempts have been made to estimate the illuminating power of coal and other gases from the analytical results they yield, but hitherto no certain method of accomplishing this has been established. Dr. Henry regarded, and not unjustly, the consumption of oxygen by a given volume of gas to be a rough estimation of its illuminating power ; but it is evident, that although generally those gases which have the highest illuminating power consume most oxygen, yet this is not always the case ; for a gas containing 10 per cent of olefiant gas, 20 per cent of light carburetted hydrogen, and 70 per cent of hydrogen, would consume much less oxygen during combustion, than one containing only 5 per cent of olefiant gas, and in which the proportion of light carburetted hydrogen and hydrogen were reversed, although its illuminating power would be twice as great.

It will be seen from what has been already said respecting the illuminating power of carbo-hydrogens, that the more dense these are, the greater does that illuminating power become. This important fact was first pointed out in reference to coal-gas, by Mr. Leigh,*

* *Memoirs of the Manchester Lit. and Philosoph. Soc.*, IX. (new series), 303.

who was also the first to make an approach towards estimating the illuminating power of gas from its analysis. Mr. Leigh regards the illuminating power of coal-gas as due to light carburetted hydrogen, olefiant gas, and hydrocarbons, and that the value of the latter is directly proportional to the quantity of oxygen required for their combustion. If we leave the light carburetted hydrogen entirely out of the calculation, as I shall prove that this gas has practically no illuminating power, this method generally gives results not far from the truth, but which are nevertheless liable to very considerable error, from the fact that the amount of oxygen consumed does not depend alone upon the luminiferous ingredients of the carbon, but also upon the amount of hydrogen combined with that element, and which is necessarily a variable quantity, being in some of the hydrocarbons in the proportion, $C : H = n : n$; in others, $C : H = n : n - 6$; and in others even, $C : H = n : n - 10$. If, however, we estimate the volume of carbon vapour contained in the luminiferous hydrocarbons, and make that the basis of our calculation, we avoid this source of error, and obtain a correct expression for the illuminating power, however much the composition of the hydrocarbons may vary. I have already pointed out a method for accomplishing this;* and Mr. Leigh, in the memoir to which I have already alluded, also describes a similar plan which he employs for the determination of the consumption of oxygen by these bodies.

The method which I have adopted in the annexed experiments is the following :

A known quantity of the gas previous to the action of sulphuric acid is exploded with an excess of oxygen, and the volume of carbonic acid produced accurately noted. Another known volume of the same gas, after the withdrawal of the hydrocarbons by sulphuric acid, is then similarly exploded with oxygen, and the carbonic acid formed also estimated. Thus the percentage amount of hydrocarbons, plus the volume generated by the non-luminous gases alone, being known, it is easy to calculate the amount of carbonic acid generated by 1 volume of the hydrocarbons. Thus if we designate the percentage of hydrocarbons absorbed by sulphuric acid, by A , the volume of carbonic acid generated by 100 volumes of the original gas, by B , the carbonic acid formed by the residual gas after absorption of hydrocarbons, by C , and the volume of carbonic acid generated by the combustion of 1 volume of the hydrocarbons alone by X , we have the following equation :

$$X = C - B$$

and therefore the amount of carbonic acid generated by 1 volume of the hydrocarbons is represented by

$$\frac{C - B}{A}$$

* Chem. Soc. Qu. J., II., 275.

but as one volume of carbon vapour generates one volume of carbonic acid, this formula also expresses the quantity of carbon vapour in 1 volume of the luminiferous constituents.

For the purpose of comparison, however, I represent the value of these hydrocarbons in their equivalent volume of olefiant gas, one volume of which contains 2 volumes of carbon vapour; for this purpose, the last expression need only be changed to

$$\frac{C-B}{2A}$$

Thus, if a gas contains 10 per cent of hydrocarbons, of which, one volume contains 3 volumes of carbon vapour, the quantity of olefiant gas to which this 10 per cent is equivalent, will be 15.

The illuminating power of the coal gases mentioned below has also been practically tested by Bunsen's photometer, and the results are corrected to those which would have been obtained by using a sperm candle, burning 120 grs. per hour; and one of these candles, burning for ten hours, is taken as the standard of comparison for the total quantity of light yielded by a given volume of gas; thus, when it is stated that the total quantity of gas produced from 1 ton of coal is equal to 1816 candles, it is intended that the light afforded by the gas is equal to that yielded by 4816 sperm candles, each burning 10 hours, and at the rate of 120 grs. per hour.

The following experiments, which I lately made at the request of two merchants of this town, upon a new process of gas-making, known as White's hydrocarbon process, serve to illustrate the principles laid down in the preceding pages.

Mr. White's process consists essentially in the generation of non-illuminating combustible gases by the action of steam upon charcoal, coke, or other substances, in a separate retort, and the introduction of these gases, along with an excess of watery vapour, into the retort in which the illuminating gases are being generated, and in such a manner, that these latter gases shall be swept out of the retort as rapidly as possible, and removed from the destructive influence of a high temperature. The excess of steam accompanying the water-gases into the second retort, performs there a remarkable office; it reacts upon the tar and fuliginous matter in a manner that will be described below, and gives rise to the formation of a great additional quantity of gas, a very large proportion of which is pure hydrogen. That this reaction of the steam should be confined entirely to the tar and other refuse matters, and should not affect the luminiferous gases generated in the same retort is scarcely conceivable, since the constitution of tar and gaseous hydrocarbons is so nearly alike; yet any destruction of illuminating principles that may be thus caused, is immensely overbalanced by the quantity of these principles, which are saved from decomposition by their rapid removal

from the influence of a high temperature, and by the vapours of volatile hydrocarbons with which the water-gases remain more or less saturated.

WHITE'S PROCESS APPLIED TO RESIN.

I. PRACTICAL RESULTS.

	1st Exp.	2nd Exp.	3rd Exp.	4th Exp.	Average.
Gas produced per ton of resin . . .	26000 cbc. ft.	28120 cbc. ft.	36820 cbc. ft.	29300 cbc. ft.	30060 cbc. ft.
Resin-oil produced per ton of resin . . .	88.9 galls.	64 galls.	41.8 galls.	84.8 galls.	69.9 galls.
Coal consumed in heating retorts . . .	1396 lbs.	1396 lbs.	1399 lbs.	1406 lbs.	1399 lbs.
Charcoal for water-gas	83 "	100 "	111 "	97 "	98 "
Water used . . .	606 "	639 "	790 "	606 "	660 "

II. ANALYTICAL RESULTS.

PERCENTAGE COMPOSITION OF PURIFIED GASES.

	1st Exp.	2nd Exp.	3rd Exp.	4th Exp.	Average.
Olefiant gas and hydrocarbons . . .	8.27	7.94	7.78	8.53	8.13
Light carburetted hydrogen . . .	18.76	45.06	22.79	32.25	29.71
Hydrogen	42.03	37.59	50.27	43.62	43.38
Carbonic oxide	30.93	9.41	19.16	15.60	18.78
	100.00	100.00	100.00	100.00	100.00

ILLUMINATING VALUE OF OLEFIANT GAS AND HYDROCARBONS EXPRESSED IN EQUIVALENT QUANTITY OF OLEFIANT GAS.

1st. Experiment.	2nd Experiment.	3rd Experiment.	4th Experiment.	Average.
11.58 per cent.	11.11 per cent.	10.89 per cent.	11.94 per cent.	11.38 per cent.

WHITE'S PROCESS APPLIED TO COALS AND CANNELS.

In order to obtain a fair comparison of the results yielded by the various coals when distilled alone (as in the usual process of gas-making) with those obtained from the same coals when treated with water-gas according to the hydrocarbon process, each coal was distilled first by itself, and then with the addition of water-gas, equal weights being used for each experiment.

I. PRACTICAL RESULTS.

Name of coal.	Cubic feet of gas per ton.		Illuminating power per ton in sperm candles.		Gain per ton by White's process.		Gain per cent by White's process.	
	By old process.	By White's process.	By old process.	By White's process.	Quantity of gas in cubic feet.	Illuminating power in sperm candles.	Quantity of gas.	Illuminating power.
Wigan cannel (Ince Hall)	10,900	16,120	4,816	6,448	5,220	1,632	47.9	33.9
Wigan ditto (Balcarres)	10,440	15,500	4,156	5,920	5,060	1,764	48.5	42.4
Boghead cannel	13,240	38,160	11,340	21,368	24,920	10,028	178.2	88.4
Ditto, 2nd exp.		51,720		20,688	38,480	9,378	290.6	82.4
Lesmahago cannel	10,620	29,180	7,620	13,934	18,560	6,314	174.8	82.8
Methyl cannel	9,560	26,400	5,316	11,088	16,840	5,772	176.2	108.6

QUANTITY OF COAL OR CANNEL REQUISITE FOR PRODUCING LIGHT EQUAL TO 1000 SPERM CANDLES, EACH BURNING TEN HOURS, AT THE RATE OF 120 GRS. PER HOUR.

Name of coal.	Weight of coal.	
	By old process.	By White's process.
Wigan cannel (Ince Hall)	465.1 lbs.	347.4 lbs.
Wigan cannel (Balcarres)	539.0 "	378.4 "
Boghead cannel	197.5 "	104.8 "
Lesmahago cannel	293.9 "	160.7 "
Methyl cannel	443.9 "	396.7 "
Newcastle coal (Pelton)	745.7 "	

II. ANALYTICAL RESULTS.

PERCENTAGE COMPOSITION OF GASES.

	Wigan cannel (Ince Hall).		Boghead cannel.		Lesmahago cannel.		Methyl cannel.		Pelton coal.
	By old process.	By new process.	By old process.	By new process.	By old process.	By new process.	By old process.	By new process.	By old process.
Hydrocarbons and olefiant gas	10.81	10.55	24.50	14.12	16.31	10.89	14.48	11.06	3.87
Light carburetted hydrogen	41.99	27.20	58.38	22.25	42.01	18.94	38.75	22.89	32.87
Hydrogen	35.94	47.39	10.54	45.51	26.84	55.09	33.32	45.58	50.05
Carbonic oxide	10.07	14.86	6.58	14.34	14.18	15.02	13.40	20.44	12.89
Carbonic acid	1.19	0.00	0.00	3.78	.66	.06	.05	.03	.32
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

ILLUMINATING VALUE OF OLEFIANT GAS AND HYDROCARBONS EXPRESSED IN EQUIVALENT QUANTITY OF OLEFIANT GAS.

Wigan cannel, by old process.	Wigan cannel, by new process.	Boghead cannel, by old process.	Boghead cannel, by new process.	Lesmahago cannel, by old process.	Lesmahago cannel, by new process.	Methyl cannel, by old process.	Methyl cannel, by new process.	Pelton coal, by old process.
per cent. 16.13	per cent. 13.72	per cent. 31.11	per cent. 19.84	per cent. 28.30	per cent. 19.05	per cent. 18.53	per cent. 14.04	per cent. 7.16

The foregoing results bring to light several circumstances highly favourable to the hydrocarbon process of gas-making, which could scarcely have been predicted previous to the actual trials being made. The first, and most important of these, is the disappearance of the carbonic acid contained in the water-gas, during its passage through the coal retort; this disappearance is so complete, that the resulting gaseous mixture actually contains a much smaller percentage than does the gas obtained by the distillation of the coal alone. There is little doubt that this removal of the carbonic acid depends upon its conversion into carbonic oxide by the carbonaceous matters in the coal retort; and of these, the coke is probably the most active, since the volatile matters do not differ materially from those produced during the distillation of resin; and these we have seen fail to remove the acid gas.

Another favourable circumstance occurring in the process, consists in the relatively small quantity of carbonic oxide that is produced. A large proportion of this gas would be equally objectionable with a high percentage of light carburetted hydrogen, on account of the quantity of carbonic acid formed during its subsequent combustion. A reference to the composition of the foregoing gases shows us, however, that in all cases, the amount of carbonic acid generated is less than that formed by the combustion of an equal volume of the gas obtained from the same coals by the ordinary process of manufacture, and in some cases it is even less than that produced by a pure coal-gas-flame giving an equal light. The favourable position which the hydrocarbon gases occupy in the above comparison, would not have been attained, if the whole, or even a very large portion of the water-gas had been generated in the charcoal retort; for when water-gas alone is generated, it is found to consist of hydrogen and carbonic oxide mixed with quantities of carbonic acid, varying from 0 to 15 per cent, according to the heat employed and other circumstances. When the percentage of the acid-gas is 0, then the volumes of hydrogen and carbonic oxide are equal; and as no important quantity of carbonic acid was ultimately present in the gases produced in the foregoing experiments, the whole of that gas entering the coal retort must be converted into carbonic oxide, and therefore we may consider the water-gas entering the coal retort as being composed of equal volumes of hydrogen and carbonic oxide. Now, if the increase in the total quantity of gas produced by the application of the hydrocarbon process to any given coal or cannel, were due only to the water-gas formed in the charcoal retort, it is obvious that the gain in carbonic oxide ought to be equal to the gain in hydrogen; but a glance at the analytical results shows that this is far from being the case. Thus, for instance, with Boghead gas, the proportion is

$$\text{Gain in H : gain in CO} = 3 \cdot 5 : 1$$

and with Lesmahago cannel,

$$\text{Gain in H : gain in CO} = 4 \cdot 6 : 1$$

It is therefore evident that a large quantity of water-gas must be generated by the action of steam upon the carbonaceous materials in the coal retort, and that this water-gas contains a very much greater percentage of hydrogen than that produced in the charcoal retort. Although we are not yet sufficiently acquainted with the action of watery vapour upon organic substances at high temperatures, to state positively the cause of this excess of hydrogen, yet there can be little doubt that it is derived from the action of steam upon the hydrocarbons of the tar. For, as watery vapour in acting upon carbon transfers its oxygen to that element, forming carbonic oxide and an equal volume of hydrogen, so also when steam acts upon a compound of carbon and hydrogen, it produces carbonic oxide, but in doing so, sets at liberty not only its own hydrogen, but that of the carbohydrogen also; and thus the volumes of hydrogen and carbonic oxide remain no longer equal, but the volume of the former becomes double, treble, or even fourfold that of the latter.

An important feature in the history of a gas for illuminating purposes, is its behaviour when exposed to cold. I have therefore submitted several of the above gases to a temperature of 32° , and carefully ascertained the loss of volume by liquefaction of hydrocarbons. These experiments, as might be expected, show that the gases made by the new process, suffer less loss by this refrigeration than those made from the same material by the old process.

Name of gas.	Cubic feet of hydrocarbons condensed from 100 cubic feet of gas, on exposure to a cold of 32° F.
Boghead, by old process	4.42 cubic feet
Ditto by new process	.24 "
Methyl, by old process	.33 "
Ditto by new process	.07 "
Ince Hall, by old process	.37 "

The percentage amount of olefiant gas contained in the Pelton gas, and the gases of the Great Central and City of London Companies, would lead us to infer that their illuminating power is much lower than is really the case; for, according to the experiments upon cannel gases, it appears that when a consumption of 5 feet per hour produces a light equal to twenty candles, the gas contains 13.72 per cent of olefiant gas, or its equivalent in richer hydrocarbons; and, hence, we should expect that a gas containing only half this amount, would, when burnt at the same rate, produce a light equal only to ten candles, instead of thirteen, as is found to be the case. This excess of illuminating power in the case of *coal* gases over that indicated by analysis, is probably owing to the presence of luminiferous

constituents not condensible either by fuming sulphuric acid, or by chlorine; the nature of these constituents, and the cause why they cannot be detected by our present methods of gas analysis, I have already pointed out.* The following table exhibits this difference between the value of olefiant gas in coal-gas, compared with that in cannel-gas, and shows also, that in the case of the latter, the illuminating power is always directly proportional to the amount of olefiant gas to which the percentage of condensible hydrocarbons is equivalent. The establishment of this rule, with regard to gases having such different percentages of light carburetted hydrogen as the Boghead gas, with and without water-gas, I hold to be conclusive evidence that light carburetted hydrogen has no higher illuminating power than hydrogen or carbonic oxide.

Value of 1 cub. ft. of the olefiant gas, contained in the following gases, expressed in sperm candles, each burning ten hours, at the rate of 120 grs. per hour.

CANNEL GASES.

	Candles.
Ince Hall cannel	2·95
" with water-gas	2·96
Boghead cannel	2·80
" with water-gas	2·86
Lesmahago cannel	2·58
" with water-gas	2·54
Ramsay's Newcastle cannel	2·88
" with water-gas	2·86
Methyl cannel	3·04
" with water-gas	3·03

COAL GASES.

	Candles.
Pelton coal	4·23
City Company's gas (coal)	3·73
Great Central Company's gas (coal)	3·91

In conclusion, the advantages resulting from the application of Mr. White's hydrocarbon process to coals and cannels may be thus summed up:

1. It greatly increases the produce in gas from a given weight of coal or cannel, the increase being from 46 to 290 per cent, according to the nature of the material operated upon.
2. It greatly increases the total illuminating power afforded by a given weight of coal, the increase amounting to from 12 to 108 per

* Chem. Soc. Qu. J. III, 42.

cent, being greatest when coals affording highly illuminating gases are used.

3. It diminishes the quantity of tar formed, by converting a portion of it into gases possessing a considerable illuminating power.

4. It enables us profitably to reduce the illuminating power of the gases produced from such materials as Boghead and Lesmahago cannels, &c., so as to fit them for burning without smoke and loss of light.

5. In addition to these positive advantages, the use of this process does not incur any additional expense in the working of the apparatus, the wear and tear of retorts, or the purification of the gas; and beyond a change of retorts, it involves no alterations in the construction of furnaces and apparatus at present employed in gas manufactories conducted on the old system.

**On the Products of the destructive distillation of Animal Substances,
Part II.**

By Thomas Anderson, M.D., F.R.S.E.*

(ABSTRACTED BY THE AUTHOR)

In a former paper on this subject, I announced the discovery, among the products of the destructive distillation of animal substances, of picoline, and described one new base to which I gave the name of petinine, and indicated the existence of several others. In examining these substances, I found that the quantity of material, though obtained from 300 pounds of bone oil, was much too small to admit of satisfactory results; the process was therefore repeated with a similar quantity of the oil, but I was again foiled by deficiency of material. The experience obtained in these preparations having enabled me to see that success could only be obtained by the use of very large quantities, I once more commenced the tedious preparation of the bases from no less than 250 gallons of the crude bone-oil.

The oil was rectified in a large cast-iron retort, furnished with a good condenser, kept cold by a current of ice-cold water. A gentle heat was applied, and the first 20 gallons, which consisted of equal bulks of a very volatile oil and water, charged with sulphide of ammonium, carbonate, and hydrocyanate of ammonia, were collected apart, and the rest of the oil received in a succession of casks which were numbered as they were filled. The watery fluid was separated from the oil, supersaturated with sulphuric acid, and boiled for a considerable time in a large copper boiler. It was then allowed to

* Edinburgh Phil. Trans. XX. 2, 247.

cool, slaked lime added in excess, a copper head and condenser attached, and heat again applied. The distillate was collected in a large glass receiver, connected by a doubly bent tube with a second, containing hydrochloric acid, for the purpose of condensing ammonia and any of the very volatile bases which might be carried along with it. The distillate, which had a powerfully ammoniacal and putrid odour, was treated with sticks of caustic potash, which caused ammonia to escape with effervescence, while a small quantity of volatile bases collected on the surface, which were separated and preserved.

The oil, of which only the more volatile half was used, was agitated with dilute sulphuric acid. After two or three days, during which the agitation was frequently repeated, more water was added and the solution drawn off. The fluid, after the addition of more acid, was then boiled for the separation of Runge's pyrrol.

In my previous experiments, I had neglected this substance, but observing now that a very powerful odour was evolved when the fluid began to boil, the head of the boiler was attached for the purpose of endeavouring to obtain it. The distilled fluid carried over with it a small quantity of a colourless oil which rapidly became red, and in the course of a few days absolutely black, and proved to be a mixture of an oil insoluble in acids, and a series of bases of very remarkable properties obviously related to one another, and which I designate provisionally by the name of *pyrrol bases*.

When these substances had been entirely expelled, for which long-continued ebullition is requisite, slaked lime was added, and the bases which had been retained by the acid distilled over. A watery solution was obtained, from which the bases were separated as an oily layer by the addition of solid caustic potash. The potash solution still containing a considerable quantity of the more volatile bases, which could only be separated by the use of a very large quantity of potash, was distilled in glass vessels, and the product collected in a succession of three receivers, the first kept cold by water, the second by a freezing mixture, and the third containing hydrochloric acid for the purpose of condensing ammonia and another gaseous base by which it was accompanied. The first receiver contained the oily bases, which could now be separated by a comparatively small expenditure of potash; in the second only a few drops of fluid were found; while the hydrochloric acid in the third was saturated with ammonia and another gaseous base. This last solution was evaporated; the chloride of ammonium, which deposited in succession crops of crystals, was separated; and at length there was obtained a dark mother-liquor which, on cooling, solidified into a mass of foliated crystals deliquescent in moist air. These were dissolved in absolute alcohol for the separation of traces of sal-ammoniac, and purified by animal charcoal. They were thus obtained in long, transparent and colourless plates, with a pungent and bitter taste. Treated with potash, they evolved a

gaseous base having an ammoniacal and putrid odour. They gave a platinum-salt in fine golden-yellow scales, the analysis of which corresponded completely with the formula, $C_2 H_9 N \cdot HCl. PtCl_2$; the base is consequently *methyamine*.

The oily bases were dried by means of caustic potash, and distilled in a retort with a thermometer. Ebullition commenced at about $150^\circ F.$; at 212° the receiver was changed, and the oil distilling above that temperature collected in fractions of 10° each. The portion boiling under 212° was rectified and collected in fractions of 5° each, which were nearly equal in bulk. They were all very similar in properties, possessing a high refractive power, and a pungent odour very like that of ammonia in the lower fractions. Exposed in the anhydrous state to a mixture of snow and salt, they remain perfectly fluid, but if a little water be added, crystals of a hydrate are deposited. The quantity of those bases which I obtained was too small to admit of complete separation by fractionated distillation; I therefore converted portions of those fractions, which I had reason to believe corresponded to particular bases, into platinum salts. I selected in the first instance the most volatile fraction, which boiled under 150° , and obtained from it a beautiful yellow salt, readily soluble in cold water, still more so in boiling water, and depositing in golden scales, which gave analytical results corresponding with the formula $C_6 H_9 N \cdot HCl. PtCl_2$. The base is therefore *propylamine*, which I have already obtained by the action of potash upon codeine. Having obtained these bases, ethylamine, the intermediate term of the same series, was next sought for; and by collecting the first few drops of the lowest fraction apart, a platinum-salt was obtained, which was obviously a mixture of those of ethylamine and propylamine, but of which the quantity was too small to admit of purification by re-crystallization. The occurrence of these bases enables us to establish satisfactorily the constitution of petinine, which must obviously be $C_8 H_{11} N$ and not $C_8 H_{10} N$, as I formerly supposed it. Indeed, the analysis of the platinum-salt contained in the first part of this paper, fully agrees with the latter formula, though that of the base itself differs from it; but much less reliance is to be placed upon that analysis, as it is difficult to obtain the base itself sufficiently pure. It thus appears that the products of destructive distillation contain ammonia and the first four members of the series of bases homologous with it; but it is probable that that series does not end here, as distinct indications of the presence of amylamine were found; and it is possible that caproamine may also be detected; but here the series ends, as when we reach a temperature of about 240° , the character of the bases alters, and we enter upon an entirely different series.

The separation of the bases, boiling above 240° , has been attended with great difficulties; but after a trial of many different processes, such as converting them into salts, exposure to cold, partial satura-

tion, &c., fractionated distillation was found the most advantageous, though even that was extremely troublesome, and I was by no means so successful in obtaining fixed boiling points, as I had been when operating on a smaller scale. All the oils, boiling above 212° , were submitted to a systematic course of fractionation, each fraction being distilled alone, and the product collected in a fresh series of receivers, which were changed at every 10° . After fourteen rectifications, the fractions, which had at first spread themselves at each successive distillation over a very large number of degrees, were confined to a comparatively small range, and it was obvious that a separation was being effected, although with extreme slowness. At this point, I endeavoured, by examination of the platinum salts obtained at different temperatures, to ascertain the constitution of the bases which those fractions contained, and knowing from previous experiments that that boiling between 270° and 280° consisted of picoline, I had indications of where these were likely to be found, and have thus been enabled to determine the existence of two bases homologous with that substance.

Pyridine.—The first of these bases, to which I give the name of pyridine, occurs in the fraction boiling about 240° . It is a perfectly transparent and colourless oil, which is not coloured by exposure to the air. Its odour is similar to that of picoline, but more powerful and pungent. It dissolves in water in all proportions, and is also readily soluble in the fixed and volatile oils. Acids dissolve it with the evolution of much heat, and the formation of highly soluble salts. With bichloride of platinum it gives a double salt in the form of flattened prisms, tolerably soluble in boiling water, less so in alcohol, and entirely insoluble in ether. When these crystals are boiled for a considerable time in water, they appear to undergo decomposition, with the formation of a platinum-salt crystallizing in golden yellow scales. The analysis of this salt gave results corresponding with the formula



The formula of the base itself must consequently be $\text{C}_{10} \text{H}_5 \text{N}$, a member of the picoline series. I have not yet extended my investigation of this base further, as the phenomena observed in the examination of the next substance showed that much difficulty would still be experienced in its purification.

Lutidine.—In the fraction boiling about 310° , occurs a base which has exactly the constitution of toluidine. The fraction obtained at 305° to 310° in the distillation of the mixed bases gives more distinct indications of a fixed boiling point, than that obtained at any other temperature. It is much less soluble than those of lower boiling points, and when dropped into a small quantity of water, floats on the surface, and is only slowly dissolved on agitation. It is less soluble

in hot than in cold water, and separates as an oily layer when its cold saturated solution is gently heated. Its odour is more aromatic than that of picoline. It unites with the acids and forms highly soluble salts. Its analysis gave results corresponding closely with the formula $C_{14}H_9N$. Notwithstanding the close correspondence of the analytical results, it appeared on further experiment that in some of the portions analyzed, appreciable quantities of picoline were present; for when a portion was converted into platinum-salt, the first crystals which deposited were found to contain 32·8 per cent of platinum, which is the number for the picoline-salt; but on evaporating, further crystals were deposited, containing 32·5 and 32·0 per cent of platinum; and the mother-liquor of these, in addition of alcohol and ether, gave a salt in flattened tables, which analysis proved to be the pure lutidine salt. This salt crystallizes in square tables, sometimes very regular, at other times confused and imperfect. It is very soluble in cold, and still more so in hot water, and is also extremely soluble in excess of hydrochloric acid. The analysis of the pure salt corresponded with the formula,



It is clear that this salt is that of the base of which the analysis has been given; but it is equally obvious that, notwithstanding the close approximation of the results to theory, the base had never been obtained absolutely pure, but had retained more or less picoline. In the course of this investigation, I have been frequently struck with the fact that when the fraction corresponding to any particular base is analyzed, results closely approximating to theory are obtained, even when the substance is very far from being pure. I found, for instance, that the portion boiling between 270° and 280° , after one or two rectifications, gave exactly the numbers for picoline, although when again rectified, it commenced boiling at about 250° , and a small quantity remained in the retort at 300° . But it is readily intelligible that this should be the case where we have to deal with a series of homologous bases, in which the percentage of carbon increases as the boiling point rises, so that we have the excess of carbon in the less volatile, counterbalancing the deficiency in the more volatile, and as each rectification removes equal quantities of the more and the less volatile bases, the percentage composition of the intermediate substance must remain unchanged.

Hydrargochloride of Lutidine.—I directed my attention to this compound, in the hope that it might prove suited to the purification of the base, but soon abandoned it, as I found it impossible to obtain invariably the same compound. When a solution of corrosive sublimate in alcohol is added to an alcoholic solution of lutidine, a curdy white precipitate falls immediately, unless the solutions be highly dilute, in which case it is deposited slowly in groups of radiated

needles. It dissolves in boiling water, with partial decomposition, and is still more soluble in spirit, from which it is deposited in crystals on cooling. Its analysis corresponded with the formula $2\text{HgCl} + \text{C}_{14}\text{H}_9\text{N}$. In another preparation, a salt was formed which corresponded nearly with the formula $3\text{HgCl} + \text{C}_{14}\text{H}_9\text{N}$, and intermediate results were also obtained; but as the existence of these different compounds appeared fatal to their employment as a means of purifying the bases, I did not pursue their examination further.

It appears then that Dippel's oil contains two series of bases, one homologous with ammonia, the other peculiar to the oil, homologous with one another, and remarkable for their isomerism with the series of which aniline is the type. Thus we have,

Pyridine	.	.	.	$\text{C}_{10}\text{H}_5\text{N}$					
Picolme	.	.	.	$\text{C}_{12}\text{H}_7\text{N}$	.	.	.	Aniline	
Lutidine	.	.	.	$\text{C}_{14}\text{H}_9\text{N}$	.	.	.	Toluidine.	

And it is probable that the series does not cease here, as I have found that the fractions of base with higher boiling points give a steadily decreasing percentage of platinum. It is impossible in the present state of the investigation to give any opinion as to the intimate constitution and relations of these two series of what may be called isohomologous bases. The most obvious explanation would be to suppose the new bases to be imidogen or nitrile bases; but into those questions I shall not now enter, but reserve their consideration for a future paper.

Pyrrol bases.—I have already referred to another series of bases which I call provisionally *pyrrol bases*, which distil away from the acid by which the others are retained. They are obtained in the form of an oil insoluble in water, and which, though at first colourless, soon becomes red, and finally black, and gives with hydrochloric acid and a piece of fir wood, the peculiar purple-red colour which Runge describes as characteristic of pyrrol. I imagined at first that I had actually obtained this substance, which had escaped me in my previous experiments, but soon found I had to deal with a mixture of several bases; for when distilled with the thermometer, it began to boil about 212° , and gave a series of fractions up to above 370° . These oils were all bases, with a peculiar and disgusting odour, quite different from, and much more disagreeable than the picoline bases. They dissolve easily in a small quantity of hydrochloric acid, and give with bichloride of platinum a yellow precipitate, which is rapidly converted into a black substance. When heated with an excess of acid, they present a very remarkable character; the solution at a certain temperature becomes filled with red flocks so abundant and bulky, that if not too dilute, it becomes perfectly solid, and the vessel may be inverted without anything escaping. The same change takes place, though more slowly, in the cold. When this substance is

collected on a filter, washed and dried, it forms a reddish-brown porous mass insoluble in water, acids, and alkalies, but soluble in alcohol.

The acid fluid separated from this substance by filtration, when supersaturated with an alkali, evolves the odour of the picoline bases, whence I infer that the pyrrol bases are in all probability coupled substances containing the picoline series in combination with some substance which yields the red matter.

I have not as yet paid much attention to the non-basic portion of bone-oil, but I have found that by repeated rectifications it improves in odour, and that benzine is contained in the more volatile portions. It is probable, therefore, that the series of homologous carbon-hydrogens to which benzine belongs, may constitute a part but not the whole of the oil, as I have found that when boiled with potash, ammonia is gradually evolved; and on saturating the potash solution with sulphuric acid, the odour of butyric acid, or at least one of the fatty acids, is evolved; whence I conclude that it also contains the nitriles of those acids.

On Rubian and its Products of Decomposition.

By Edward Schunck, F.R.S.

(ABSTRACTED BY THE AUTHOR.)

PART I.

Among the many discussions to which the subject of madder has given rise among chemists, there is none which is calculated to excite so much interest as that concerning the state in which the colouring matter originally exists in the root, and there is no part of this extensive subject which is at the same time involved in such obscurity. It is a well-known fact, that the madder-root is not well adapted for the purposes of dyeing until it has attained a growth of from eighteen months to three years, and that after being gathered and dried, it gradually improves for several years, after which it again deteriorates. During the time when left to itself, especially in a state of powder, it increases in weight and bulk (in consequence, probably, of absorption of moisture from the air), and some chemical change is effected, which, though not attended by any striking phenomena, is sufficiently well indicated by its results. There are few chemical investigations that have thrown any light on the nature of the process which takes place during this lapse of time, and, in fact, most of the attempts to do so have merely consisted of arguments based on analogy. It has been surmised that the process is one of oxidation, and that the access of atmospheric air is consequently necessary; but a more general supposition is, that the process is one of fermentation, attended perhaps by oxidation. What the substance is, however, on which this

process of oxidation or fermentation takes effect, and what the products are which are formed by it, are questions which have never been satisfactorily answered. It has indeed been suspected by several chemists, that there exists originally some substance in madder, which by the action of fermentation or oxidation, is decomposed, and gives rise by its decomposition to the various substances endowed either with a red or yellow colour, which have been discovered during the chemical investigations of this root; and to this view Persoz, in his "*Traité de l'Impression des Tissus*,"* gives his assent.

To Mr. J. Higgin† is due the merit of having first called attention to the fact, that important changes take place during the process of dyeing with madder, which can only be explained by supposing that an actual formation of colouring matter takes place during the process. Mr. Higgin concluded from his experiments that a formation of part of the colouring matter, during the dyeing process, is due to the peculiar substance, called by Kuhlmann, *Xanthine*.

A very simple experiment suffices to prove that madder, in its dry state, contains very little, if any alizarine ready formed. If an extract of madder be made with cold water, it will be found that the brownish-yellow liquid thus obtained, when gradually heated, will dye as well and as strongly as the madder from which it has been pressed. Now, if the colouring matter were originally present in the form of alizarine, this could not take place, since alizarine is almost insoluble in cold water; and in employing it for the purpose of dyeing, it is necessary to dissolve it in warm or boiling-water, before it begins to exert any effect, as is plainly seen in the case of garancine, which contains alizarine ready formed.

By adding a variety of substances to an extract of madder with cold water, I was enabled to ascertain under what circumstances, and by what means the tinctorial power of the liquid is destroyed, and consequently what is the general character of the substance or substances to which it is due. I found that by adding sulphuric or muriatic acid to the extract and heating, the liquid, after neutralisation of the acid, was no longer capable of dyeing. The tinctorial power was also destroyed by the addition of hydrate of alumina, magnesia, protoxide of tin, and various metallic oxides, but not by carbonate of lime or carbonate of lead. In all cases in which the property of dyeing in the extract was destroyed, I invariably found that its bitter taste and bright yellow colour were lost. In my former papers on this subject, I have shown that the intensely bitter taste of madder and its extracts is due to rubian; and hence it follows that this substance, though itself no colouring matter, is in some way concerned in the changes when by a formation of colouring matter is induced in aqueous extract of madder.

* T. I., 501.

† On the Colouring Matters of Madder, by J. Higgin, Phil. Trans. for Oct. 1848.

The preparation of rubian in a state of purity is attended with difficulties, in consequence of the facility with which it is decomposed by most reagents. There is also another circumstance which presents obstacles to almost all attempts to obtain it pure. There is no investigation of madder which does not make mention of a substance, which when its watery solution is mixed with sulphuric or muriatic acid, and boiled, gives rise to the formation of a dark green powder. To this substance, which possesses no bitter taste, and is in fact devoid of any characteristic property except the one mentioned, I have restricted the name *xanthine*. The xanthine of most other chemists is, however, a mixture of rubian with this substance, and possesses therefore the bitter taste of the former, while showing the characteristic behaviour of the latter towards acids. To avoid confusion, I shall no longer employ the name of xanthine, and I shall call the substance which gives the green powder, with acids, *chlorogenine*. Now these two substances, though of very different nature, behave similarly towards many reagents. Chlorogenine, for instance, is not precipitated by basic acetate of lead, when it is contained alone in solution; but it is partly precipitated thereby, when rubian is present at the same time.

After numerous experiments I discovered a property of rubian, which is perhaps more characteristic of it than any other, and that is the remarkable attraction which is manifested by it towards all substances of a porous, or finely-divided nature; and it was this property by means of which I was enabled to obtain it in a state of purity. If to a watery extract of madder, a quantity of protochloride of tin be added, a light, purple-lake is precipitated. Most of the rubian remains in the solution, which still retains its yellow colour and bitter taste. If, however, after filtering, sulphuretted hydrogen be passed through it, then provided the quantity of tin, still in solution be sufficiently large, the sulphuret of tin at the moment of precipitation, carries down the whole of the rubian, and the solution loses its bitter taste, and the greater part of its yellow colour. The whole of the chlorogenine remains in solution, and may easily be detected in the filtered liquid by means of acids. If the sulphuret of tin, after being collected on a filter, and well washed with cold water until the percolating liquid no longer gives a green colour on being mixed with acid and boiled, be treated with boiling alcohol, a yellow solution is obtained, which, on evaporation, gives pure rubian, without any admixture of chlorogenine, in the shape of a dark yellow, brittle substance. The same effect is produced by sulphuret of lead. If sugar of lead be added to an extract of madder, a dark, reddish-brown precipitate falls, the liquid still containing the rubian of the extract, as seen by its deep yellow colour and bitter taste. If sulphuretted hydrogen be now passed through the filtered liquid, a great part of the rubian goes down with the sulphuret of lead, and may again be separated from it by means of boiling alcohol.

This attraction of surface exerted towards rubian by bodies in a state of minute division, is not confined to metallic sulphurets. A very small quantity of animal charcoal is sufficient to deprive an aqueous extract of madder of its bitter taste and its tinctorial power. Lamp-black acts in the same manner, though much less powerfully. Wood charcoal, however, has no absorbent effect whatever on rubian. All these substances attract rubian alone, leaving the other substances contained in the extract, such as chlorogenine, sugar, and pectine, untouched. By means of boiling alcohol, part of the rubian in combination with them is again removed, and thus an easy and efficient means is given of obtaining rubian in a state of purity.

The following method of operation I have found best adapted for the purpose. A weighed quantity of madder being placed on a piece of calico or fine canvas, stretched on a wooden frame, boiling water is poured on it, in the proportion of 4 quarts of water to 1 of madder. A dark yellowish-brown liquor is obtained, to which there is added, while hot, for every pound of madder taken 1 oz. of animal charcoal. The liquid being well stirred with the charcoal, the latter is allowed to settle, which it does in a very short time, and the liquid, which still retains a brown colour, is decanted. The charcoal is then placed on a piece of calico, or on a paper filter, and washed with cold water, until the percolating liquid, when mixed with muriatic acid and boiled, no longer acquires a green colour, which is a sign that the chlorogenine is removed. The animal charcoal is now treated with boiling alcohol, which is filtered boiling hot, and the treatment is repeated until it no longer communicates to the alcohol any yellow colour. The alcohol is now evaporated. During evaporation, a small quantity of a dark flocculent substance is deposited, which is separated by filtration. The solution still contains a small quantity of another substance, which is a product of decomposition of rubian itself, and is probably formed by the application of too great a heat in the process of drying the madder. This substance may be removed by adding sulphuric acid to the cold solution after the greatest part of the alcohol has been removed. The sulphuric acid completely decomposes the foreign substance, provided a sufficient quantity is employed, and converts it into a substance which renders the solution milky, and then falls in the shape of brown resin-like drops. The sulphuric acid being neutralized with carbonate of lead, the filtered solution, which is yellow, and now contains pure rubian, is carefully evaporated to dryness. From 1 cwt. of madder, I obtained in this manner about 1000 grs. of rubian.

As thus prepared, rubian has the following properties. It is a hard, dry, brittle, shining, perfectly uncrystalline substance, similar in appearance to gum or dried varnish. It is not deliquescent, as xanthine is described to be. In thin layers it is perfectly transparent,

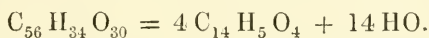
and of a beautiful dark yellow colour. In large masses it is dark brown. It is very soluble in water and alcohol, more so in the former than the latter, but insoluble in ether. Its solutions have an intensely bitter taste. Its watery solution gives no precipitates with the mineral or organic acids, nor with salts of the alkali or alkaline earths. The only metallic salt which precipitates it from its solution is basic acetate of lead. The precipitate is light red. Concentrated sulphuric acid dissolves rubian with a blood-red colour; on boiling the solution, it becomes black and disengages sulphurous acid. Dilute sulphuric and muriatic acids decompose it on boiling in a manner to be described below. Nitric acid changes it into the acid which I called in my former papers alizaric acid, and which Laurent and Gerhardt consider as identical with naphthalic acid. Phosphoric, oxalic, tartaric, and acetic acids, produce no effect on rubian. When a stream of chlorine gas is passed through a watery solution of rubian, the solution immediately becomes milky, and begins to deposit a lemon-yellow powder, into which, on continuing the action, the whole of the rubian is converted, the liquid becoming colourless. Caustic soda turns the colour of a solution of rubian from yellow to blood-red, which on boiling the liquid again changes to purple. When heated on platinum-foil, rubian melts, swells up very much, burns with a flame, and leaves a carbonaceous residue. When heated gradually in a tube, it begins to undergo decomposition, accompanied by loss of water, at a temperature of about 130° C. When heated still further, it gives fumes of an orange colour, which condense on the colder parts of the vessel to a crystalline mass, consisting chiefly of alizarine.

The composition of rubian is expressed by the formula $C_{56}H_{34}O_{30}$, that of its lead-compound by $C_{56}H_{34}O_{30} + 6 PbO$.

Action of sulphuric and muriatic acid on rubian.—The action of these two acids is precisely the same; but for the purpose of studying it, it is better to employ sulphuric acid, as it is more easily removed again afterwards. On adding sulphuric acid in considerable quantity to a watery solution of rubian, and boiling the liquid, no perceptible change takes place at first, except that the solution loses a little of its transparency, and becomes slightly opalescent. After boiling for some time, the rubian is entirely decomposed. On allowing to cool, a quantity of orange-coloured flocks are deposited, while the liquid becomes almost colourless. The orange-coloured flocks are separated by filtration, and washed with cold water, until all the acid is removed. They now consist of four different substances, viz.: firstly, *Alizarine*; secondly, the substance which in my former papers I have called *alpha-resin*, but to which I prefer giving the name of *Rubiretine*; thirdly, the substance which I formerly termed *beta-resin*, but which I shall now call *Verantine*, from *Verantia*, the name applied to madder in the middle ages. The fourth substance has

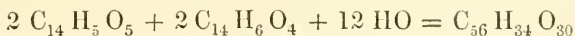
not hitherto been observed. I shall call it *Rubianine*. On dissolving the mixture of these four substances in a small quantity of boiling alcohol, the rubianine separates, on the solution cooling, as a brownish-yellow crystalline mass, and is purified by recrystallization from boiling alcohol. On adding acetate of alumina to the alcoholic liquid, a dark red precipitate falls, which consists of alizarine and verantine in combination with alumina. The compound is decomposed with acid; the mixture of alizarine and verantine is again dissolved in alcohol; and the verantine is precipitated by means of acetate of copper, a compound of alizarine and oxide of copper remaining dissolved in the alcohol, and forming a dark purple solution. The rubiretine is contained in the liquid from which the alizarine and verantine have been precipitated by acetate of alumina. The acid liquid from which the orange-coloured flocks were deposited, contains a species of *sugar*, which is obtained by neutralising the acid with carbonate of lead, and evaporating.

The analysis of the alizarine formed in this process led to the same formula, at which I had previously arrived, viz., $C_{14}H_5O_4$, and this formula receives a new confirmation from the relation in which it stands to that of rubian. The formation of alizarine from rubian admits of a very easy explanation. By simply losing 14 equivs. of water, 1 equiv. of rubian is converted into 4 equivs. of alizarine; for:



The properties of verantine are identical with those of the substance to which I formerly gave the name of the beta-resin of madder. Its composition is expressed by the formula $C_{14}H_5O_5$, which was confirmed by the analysis of the baryta and copper compounds.

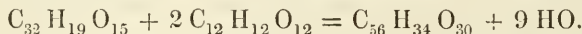
The most probable formula for rubiretine is $C_{14}H_6O_4$. If, therefore, 2 equivs. of verantine, 2 equivs. of rubiretine, and 12 equivs. of water, be added together, the sum will be equal to 1 equiv. of rubian; for,



Rubianine is soluble in boiling alcohol and water, from which it crystallizes, on the solutions cooling, in bright, lemon-yellow, silky needles, which, when dry, form an interwoven mass. When heated it is carbonised without being volatilised. It is not decomposed by boiling nitric acid. It dissolves in solutions of alkalis with a blood-red colour, but after some time is again deposited unchanged. Its alcoholic solution gives no precipitate with sugar of lead. It is not converted into rubiacic acid by means of persalts of iron, by which it is chiefly distinguished from rubiacine. Its composition is expressed by the formula $C_{32}H_{19}O_{15}$.

The sugar mentioned above as the fifth product of the action of

acids on rubian is obtained in the form of a yellow transparent syrup, which neither crystallises, however long its solution may be left to stand, nor becomes dry, unless heated to 100° C. Its taste is sweetish, accompanied by a bitter after-taste, like that of burnt sugar. It is easily decomposed by caustic alkalies; but not so easily by dilute sulphuric acid. Nitric acid converts it into oxalic acid. By fermentation it yields alcohol. Its composition is identical with that of grape-sugar, its formula being $C_{12}H_{12}O_{12}$. Hence, it follows, that 1 equiv. of rubian takes up 9 equivs. of water, and then splits up into 1 equiv. of rubianine, and 2 equivs. of sugar, for



In the opinion of most chemists who have examined madder, this root contains two distinct colouring matters, viz., alizarine, and another, to which the names of *purpurine*, *oxylizaric acid*, and *madder-purple*, have been applied by different chemists. I have, however, reason to suppose that the latter is in fact no distinct colouring matter, but a mixture of alizarine and verantine. As a characteristic of purpurine, is mentioned its property of forming, when treated with boiling alum-liquor, a red, opalescent solution, from which it separates again in orange-coloured flocks on the solution cooling. Pure alizarine is not more soluble in boiling alum-liquor than in water; it only communicates to the liquor a yellow colour. Verantine is still less soluble in alum-liquor. If, however, a mixture of alizarine and verantine be dissolved in caustic alkali, and they be then precipitated together by means of a solution of alum added in excess, then, on boiling the precipitate with the liquid, a bright red solution is obtained, and on filtering and allowing to cool, orange-coloured flocks are deposited, while the liquid still remains red, but gives a yellow precipitate on the addition of acid. From this experiment, I am inclined to infer that alizarine and verantine are capable of forming a double compound with alumina, soluble in boiling water, and that a mixture of the two in the proportion in which they exist in this compound, constitutes what has been called purpurine.

On Aspartic and Malic Acids.

By L. PASTEUR.*

In a former memoir, the author has shown that aspartic and malic acids have the power of turning the plane of polarization of luminous rays, and that this power likewise extends to all their saline compounds; moreover, that fumaric acid, as formed in nature, and likewise

* Compt. rend. XXXIII, 217; Ann. Ch. Phys. [3] XXXIV, 30.

as it is obtained by the dry distillation of malic acid, does not possess this property. About the same time, M. Dessaignes announced the transformation of acid fumarate of ammonia into malic acid. On comparing the results obtained by Dessaignes with those of Pasteur, it would appear that aspartic acid, a substance possessing rotatory power, may be obtained artificially from acid fumarate of ammonia, a substance which is destitute of that property. Now, as such a result would be contrary to all previous experience, the author was disposed to conclude that the aspartic acid formed by Dessaignes differed from natural aspartic acid—that, namely, which is formed from asparagine—by the absence of molecular rotatory power. Accordingly, he obtained from M. Dessaignes a specimen of the aspartic acid prepared from fumarate of ammonia, and on examining it, found that it was really destitute of rotatory power, although in its chemical properties, it exhibited the most exact resemblance to natural aspartic acid.

It became therefore peculiarly interesting to examine the transformation of this substance into malic acid. It is well known that malic acid may be readily formed from asparagine and aspartic acid; and the author has shown that the acid thus obtained is identical, in its chemical, crystallographical, and optical properties, with the malic acid of the service-tree, the apple, and the grape. Now, on treating the new aspartic acid of Dessaignes by a method exactly similar to that by which Piria obtained malic acid from asparagine, a malic acid was produced which was likewise destitute of rotatory power. The author proposes to distinguish these acids and their derivatives by the names actually in use, with the addition of the epithets *active* and *passive*; e. g., *active malic acid*, *active aspartic acid*, *inactive malic acid*, *inactive aspartic acid*.

A comparison of the properties of these active and passive compounds presents very curious and unexpected results. With the exception of a few dissimilarities, for the most part of minor importance, these substances are, chemically speaking, undistinguishable. Every reaction which can be produced by one of the active acids, may likewise be obtained, under similar circumstances, with the corresponding passive acid; and the resulting compounds have always the same ultimate composition and the same chemical properties. Thus, active malic acid, when heated to nearly 150°C ., is transformed into two volatile acids, the *maleic* and *fumaric*. The same phenomenon is presented by inactive malic acid. Active malate of lead fuses at a temperature below 100° ; so likewise does the inactive malate. Active malate of lead, which is amorphous when first precipitated, subsequently crystallizes in silky tufts; inactive malate of lead exhibits the same property. All the active malates and aspartates, without exception, have their analogues among the inactive malates, which latter are obtained by exactly the same processes as the active

salts. Lastly, the corresponding salts have always the same chemical formula.

The crystalline forms of the corresponding active and inactive compounds present some remarkable peculiarities, being sometimes totally distinct and incompatible, sometimes sensibly the same and with the same angles. Thus, active aspartic acid and aspartate of soda crystallize in the system of the right prism with a rhombic base, whereas the corresponding inactive compounds crystallize in the system of the oblique prism with rectangular base, which is incompatible with the preceding. On the other hand, the active bimalates of lime and ammonia crystallize in the system of the right prism with rhombic base, and the corresponding inactive bimalates, not only crystallize in the same system, but likewise with the same angles; there is this difference, however, that the active substances always exhibit hemihedral faces, which the inactive compounds never do. It appears then, that the molecular constitution of the inactive substances is not incompatible with a crystalline form identical with that of the corresponding active compounds; and we may presume with tolerable certainty that where the forms appear incompatible, the incompatibility is due to dimorphism.

The phenomena above described might induce the supposition that the inactive varieties of aspartic and malic acid might each be separated into two other acids, one of which would turn the plane of polarization to the right, and the other to the left, in the same manner as racemic acid is separated into dextroracemic and lævoracemic acid. This supposition, however, is untenable. For, in the first place, the difference between racemic and tartaric acid is much greater than that which exists between active and inactive malic acid. Thus, the chemical composition of a racemate is rarely identical with that of the corresponding tartrate; and, in the few cases in which this identity of composition exists, the racemate is separable by crystallization into a dextro- and a lævo-tartrate. But the chief objection to the above-mentioned supposition is derived from the mode of production of inactive aspartic and malic acids. Inactive aspartic acid is in fact derived from maleic and fumaric acids. If then it possesses a binary constitution, an analogous constitution must be supposed to exist in the acids from which it is derived—unless indeed we suppose that the maleic and fumaric acids are transformed by heat into binary *symmetrical* groups—a change which there is even greater difficulty in conceiving. Now, to suppose a binary constitution in fumaric and maleic acids, is to admit that the action of heat transforms a molecule of active malic acid into binary groups of two active molecules identical in form, but not superposable. On the other hand, it is reasonable to suppose that a molecular arrangement unsymmetrically constituted, may, when exposed to an elevated temperature, be changed into another molecular arrangement, in

which the peculiar disposition which produced the want of symmetry in the first arrangement, has disappeared.*

The results above described throw a new light on the molecular constitution of bodies. The author had shown in former researches, that substances capable of acting on polarized light, may be compared to those groups, so frequent in the vegetable and animal kingdoms, in which the want of symmetry is of that nature that we may imagine other groups identical with them in form, but not superposable; *e. g.*, the right and left members of the body, and those plants in which the points of insertion of the leaves form a right-hand or a left-hand spiral. In one case (that of tartaric acid) the left-hand modification corresponding to the right-hand variety previously known, was actually discovered. In the present instance, we see that compounds exerting a rotatory power on polarized light may be so little altered in their molecular grouping, as to retain without exception all their chemical properties, and merely to lose that peculiar unsymmetrical molecular grouping, which produces the right or left-handed character.

The only known substances which can be compared with those just considered are ordinary active oil of turpentine, and the inactive variety obtained by the action of heat and caustic lime on the artificial solid camphor of turpentine. It is highly probable, however, that this new kind of isomerism is a general property of substances possessing the rotatory power, and that examples of the same kind will be multiplied, now that the attention of chemists has been drawn to this new class of compounds.

A remarkable similarity appears to exist between the molecular constitution of ordinary malic acid and that of tartaric acid. Biot, it is well known, has discovered several remarkable peculiarities in the action of tartaric acid upon light, *viz.*: 1. That its rotatory power increases with the proportion of water which it contains; 2. That this power is increased by elevation of temperature; 3. By the presence of boracic acid; 4. That the mode of dispersion of the planes of polarization does not follow the law of the inverse squares of the lengths of the wave, which is found to be very nearly true in quartz and in most substances possessed of molecular rotatory power. These four exceptional laws have hitherto been considered quite peculiar to

* Bimalate of ammonia becomes inactive by the abstraction of 5 atoms of water at 200° C., and aspartic acid by the loss of 3 atoms. The loss of rotatory power may be attributed to several causes: 1. The action of heat. 2. The expulsion of water, the molecular group before the loss of water, being unsymmetrical, in consequence of the disposition of the atoms of water in the midst of it. 3. We may suppose that the rotatory power was due to the relative arrangement of the molecules of water and of the de-hydrated substance. It would be very useful towards the solution of this important question, to abstract the molecules of water from the active groups at low temperatures, and ascertain whether the rotatory power is destroyed under those circumstances.

tartaric acid. Pasteur, however, finds that active malic acid exhibits the same peculiarities. There must therefore be some intimate relation between the molecular constitution of tartaric and of malic acid; and it must be especially remarked that this analogy of constitution is shown by a dissymmetric phenomenon, viz., the optical rotatory power. Hence it follows, independently of any theoretical generalizations of the facts relating to right and left-handed substances—that since there are two varieties of tartaric acid, the one right and the other left-handed, there must likewise exist two corresponding varieties of malic acid. It matters little whether the variety of malic acid, which is *symmetrical* to the ordinary malic acid known to chemists, exists or not in any particular plant. That which we may safely assert, is the possible existence of this variety of malic acid, *symmetrical* or *non-superposable* to the acid of the service-tree, of the apple, and the grape.

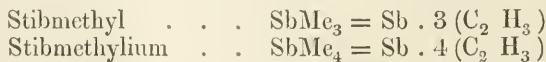
The ordinary active variety of malic acid corresponds to *dextro-tartaric acid*, a fact which might have been predicted from the constant simultaneous existence of malic acid and dextro-tartaric acid in all acid fruits. It is very probable that when the kind of grape which yielded tartaric acid containing racemic acid shall have been rediscovered, this same grape will be found to contain the *lævo-malic* acid, symmetrical to ordinary malic acid.

Another consequence which may be deduced from the preceding facts, is the possible existence of an inactive asparagine corresponding to the inactive malic and aspartic acids; and when we shall have discovered the mode of preparing ordinary active asparagine from active malic or aspartic acid, the same reaction applied to the corresponding inactive acids will doubtless produce inactive asparagine.

There are also strong reasons for presuming the existence of an inactive tartaric acid corresponding to inactive malic acid. This acid would be neutral to polarized light, like racemic acid, but would differ from the latter in molecular constitution, and would not be separable into two symmetric acids.

Organic Bases containing Antimony.*

The compounds of this class discovered up to the present time are as follows :



* Löwig and Schweitzer, Ann. Ch. Pharm. LXXV, 315, 327; J. pr. Chem. XLIX, 385; L, 321; Pogg. Ann. LXXX, 338; Chem. Gaz. 1850, 201, 372, 395, 420. —Landolt, Ann. Ch. Pharm. LXXVIII, 91; Löwig, *Grundriss der Organischen Chemie*, Braunschweig, 1852, S. 383.

Stibethyl	$\text{SbAc}_3 = \text{Sb} . 3 (\text{C}_1 \text{H}_5)$
Stibethylium	$\text{SbAc}_4 = \text{Sb} . 4 (\text{C}_4 \text{H}_5)$
Stibamyl	$\text{SbAm}_3 = \text{Sb} . 3 (\text{C}_{10} \text{H}_{11})$

The compounds SbMe_3 , SbAc_3 , and SbAm_3 are obtained by distilling the iodide of methyl, ethyl, or amyl, with antimonide of potassium. They all oxidize very rapidly; and therefore in preparing them, the same precautions must be taken as in the preparation of cacodyl, viz., to exclude the air completely, and conduct the whole operation in an atmosphere of carbonic acid.

These compounds have remarkably strong combining tendencies, and unite at ordinary temperatures with oxygen, sulphur, selenium and the halogens, the act of combination being attended with considerable evolution of heat, sufficient in the case of stibmethyl and stibethyl, to produce inflammation.

The compounds formed with the elements just named, resemble in all their relations, the corresponding potassium-compounds, and may be transformed one into the other, by mutual decomposition. The so-called basic radicals, however, containing 3 eq. of methyl, &c., combine with 2 eq. of oxygen, sulphur, chlorine, &c., a character by which they also differ from cacodyl. The compounds containing 4 eq. of methyl or ethyl are precisely analogous to ammonium, combining only with 1 eq. of oxygen, sulphur, chlorine, &c. These last-mentioned compounds are formed by the action of iodide or bromide of methyl or ethyl on stibmethyl or stibethyl, in which case the haloid-compounds SbMe_4I , SbAc_4I , &c., are produced.

Stibmethyl, SbMe_3 .—This compound is a colourless, heavy liquid, which has peculiar odour, is insoluble in water, but dissolves sparingly in alcohol, and readily in ether. When exposed to the air, it gives off thick white vapours, takes fire, and burns with a blue flame, with separation of metallic antimony.

Stibmethylum, SbMe_4 .—Not yet obtained in the separate state.

Oxide of Stibmethylum, $(\text{SbMe}_4)\text{O} + \text{HO}$.—This compound is obtained by agitating an aqueous solution of iodide of stibmethylum $(\text{SbMe}_4)\text{I}$, with recently precipitated oxide of silver, filtering from the iodide of silver, and evaporating the filtrate *in vacuo* over sulphuric acid. White crystalline mass, having a highly caustic, alkaline taste, and analogous in all its relations to caustic potash. Dissolves readily in water and alcohol, but very sparingly in ether. Volatilizes unchanged at a high temperature. Heated with potassium, it gives off a spontaneously inflammable gas. This base saturates acids completely, forming salts precisely corresponding to the salts of potash; it likewise expels ammonia, and even baryta and lime, as well as all the heavy metallic oxides, from their combinations. The

precipitate which it forms in solutions of zinc and alumina, dissolves in excess of the precipitant. From copper-salts it throws down hydrated oxide of copper, insoluble in excess of the base, and does not dissolve a trace of oxide of silver. All its salts have a bitter taste.

Sulphate of Stibmethylium.— α . *Neutral.* $(\text{SbMe}_4)\text{O} \cdot \text{SO}_3$ or $\text{SbMe}_4 \cdot \text{SO}_4$.—Obtained by adding sulphate of silver to an alcoholic solution of the iodine-compound, filtering from the iodide of silver, and treating the filtered liquid with a mixture of alcohol and ether; or by adding the oxide of stibmethylium to a concentrated solution of the acid salt, till the acid reaction disappears, and then mixing the aqueous solution with alcohol containing ether. It first separates in oily drops, which however soon solidify, and form rhombic prisms.

β . *Acid sulphate,* $(\text{SbMe}_4)\text{O} \cdot \text{HO} \cdot 2\text{SO}_3$ or $\text{SbMe}_4\text{SO}_4 + \text{H}_2\text{SO}_4$.—Obtained by evaporating a solution of the neutral salt over the water-bath. Crystallizes in very beautiful square tables with truncated summits; they are very hard, dissolve readily in water, and with tolerable facility in alcohol; their taste is first sharp, and afterwards bitter.

Nitrate of Stibmethylium.—Formed by treating a solution of the iodide with nitrate of silver. It is soluble in water; has a rough and bitter taste; crystallizes in small needles; and detonates when heated.

Bicarbonate of Stibmethylium, $(\text{SbMe}_4)\text{O} \cdot \text{HO} \cdot 2\text{CO}_2$ or $\text{SbMe}_4 \cdot \text{CO}_3 + \text{HCO}_3$.—Formed by completely saturating the pure base with carbonic acid. Crystallizes in small needles arranged in stellate groups. Dissolves easily in water, has a slightly alkaline and bitter taste, and gives no precipitate with neutral magnesia-salts.

Iodide of Stibmethylium, SbMe_4I .—Formed, as above-mentioned, by bringing stibmethyl in contact with iodide of methyl. Crystallizes in very beautiful six-sided tables, easily soluble in water and alcohol, sparingly in ether. Its taste is first saline, afterwards bitter. When heated in a test-tube, it gives off vapours which take fire spontaneously in the air, antimonious acid being separated at the same time. Acids separate iodine from this compound; the iodine may also be precipitated by silver-salts.

Iodide of Stibmethylethylum, $\text{SbMe}_3\text{Ae} \cdot \text{I}$.—Obtained by mixing stibmethyl with iodide of ethyl; it closely resembles the preceding compound.

Chloride of Stibmethylium, SbMe_4Cl .—Obtained by evaporating the iodine with strong hydrochloric acid, and evaporating, or by decomposing the iodide with corrosive sublimate; but the best mode of obtaining it, is to saturate a solution of pure oxide of stibmethylium with hydrochloric acid, and evaporate. This compound forms

white crystals, which are easily soluble in water, less soluble in alcohol, and quite insoluble in ether; they have a bitter taste, and, in other respects are precisely analogous to the iodine-compound.

Stibethyl, $\text{SbAc}_3 = 4$ vol. gas.—This compound forms a transparent, colourless, extremely mobile liquid, having a strong refracting power, and a disagreeable alliaceous odour, which, however, is very transient. It is insoluble in water, but dissolves readily in alcohol and ether. Does not solidify at -29°C ., boils at 158.5° . Spec. grav. = 1.3244. Vapour-density = 7.44.

Oxide of Stibethyl, $(\text{SbAc}_3) \text{O}_2 + 2 \text{HO}$.—When stibethyl is introduced in a fine jet into oxygen gas, it immediately takes fire, and burns with a dazzling white light; the same effect is produced in the air, excepting that the ignition does not take place till after several seconds, and is preceded by the formation of a thick, white fume. If, however, the oxidation proceeds slowly, a transparent, syrupy mass is obtained, consisting of $(\text{SbAc}_3) \text{O}_2 + 2 \text{SbO}_3^*$ (the so-called *ethylo-stybelic acid*). The oxide is obtained in a state of purity by precipitating the sulphate with baryta-water, and separating the baryta which still remains in the filtrate by carbonic acid. On evaporating the liquid, the oxide remains in the form of a viscid, transparent, and perfectly colourless mass, presenting no traces of crystallization. It dissolves readily in water and alcohol, sparingly in ether; has a bitter taste, is not poisonous, and does not excite vomiting. It is not volatile. Oxide of stibethyl behaves like an inorganic base, and forms with acids, a number of crystallizable salts which are very soluble in water.

Sulphate of Stibethyl, $(\text{SbAc}_3) \text{O}_2 \cdot 2 \text{SO}_3$, is obtained by decomposing sulphide of stibethyl with sulphate of copper. Crystallizes in small, white prisms, which are inodorous, have an acid reaction, a bitter taste, and are soluble in water and alcohol.

Nitrate of Stibethyl, $(\text{SbAc}_3) \text{O}_2 \cdot 2 \text{NO}_3$.—Stibethyl takes fire with explosion when brought in contact with fuming nitric acid. In dilute nitric acid, it dissolves like a metal, with evolution of nitric oxide gas. This salt crystallizes from its aqueous solution, by spontaneous evaporation, in large, transparent, rhomboidal crystals, which dissolve easily in water and alcohol, have an acid reaction, a bitter taste, and fuse at 62.5° . It deflagrates when heated.

* This is the formula given in Löwig's recently published *Grundriss der Org. Chem.* But in the original paper by Löwig and Schweitzer (Ann. Ch. Pharm. LXXV), it is stated that the slow oxidation of stibethyl yields two products, viz., a syrupy mass consisting of oxide of stibethyl $(\text{SbAc}_3) \text{O}_2$, and a white powder insoluble in ether, consisting of $(\text{SbAc}) \text{O}_3$. This latter compound is called *Aethylstylsäure*, the radical SbAc being called *Aethylstihyl*.

Sulphide of Stibethyl, $(\text{SbAc}_3) \text{S}_2$.—When an ethereal solution of stibethyl is boiled with washed flowers of sulphur, and the warm ethereal solution decanted from the excess of sulphur, the whole liquid solidifies in a few minutes, forming a mass of dazzling white crystals, which smell like mercaptan, dissolve easily in water and alcohol, and when heated above 100° , fuse into a colourless liquid. The introduction of a piece of potassium into the fused sulphide of stibethyl, causes an immediate evolution of vapours of stibethyl. The solution of sulphide of stibethyl precipitates all metallic salts as sulphides; dilute acids immediately decompose it, with evolution of sulphuretted hydrogen. Sulphide of stibethyl is not volatile. With SbS_3 it forms a yellow, insoluble compound, which smells like mercaptan, and contains $(\text{SbAc}_3) \text{S}_2 + 2 \text{SbS}_3$.

Selenide of Stibethyl.—Similar in composition and properties to the sulphide; it suffers decomposition, however, when exposed to the air, selenium being separated.

Iodide of Stibethyl, $(\text{SbAc}_3) \text{I}_2$.—Formed by adding iodine in small quantities to an alcoholic solution of stibethyl, as long as its colour disappears, and then diluting the alcoholic solution. Crystallizes in long, perfectly colourless needles; has a faint odour, a bitter taste, and is easily soluble in water, alcohol, and ether; fuses at 70° , and may be sublimed by careful heating. With chlorine, bromine, acids, and metallic salts, it behaves exactly like iodide of potassium; nitrate of silver immediately forms with it a precipitate of iodide of silver.

Bromide of Stibethyl, $(\text{SbAc}_3) \text{Br}_2$.—When bromine is added drop by drop to stibethyl, each drop produces combustion. But by adding bromine in very small quantities, as long as its colour disappears, to an alcoholic solution of stibethyl, which must be kept cold, and then mixing the solution with a large quantity of water, bromide of stibethyl separates in the form of a perfectly colourless, transparent liquid, which at -10° , solidifies in a snow-white, crystalline mass. It has an unpleasant odour, like that of turpentine, excites a copious flow of tears when heated; is insoluble in water, but dissolves readily in alcohol and ether; it is not volatile. In its chemical relations, it is precisely analogous to bromide of potassium.

Chloride of Stibethyl, $(\text{SbAc}_3) \text{Cl}_2$.—When stibethyl is dropped from a narrow tube into a flask filled with chlorine, it takes fire at the instant of contact. Hydrochloric acid gas is decomposed by stibethyl, with evolution of hydrogen and formation of chloride of stibethyl; the same action takes place when strong hydrochloric acid is poured upon stibethyl. On mixing a solution of nitrate of stibethyl with strong hydrochloric acid, chloride of stibethyl immediately separates in the form of a colourless, strongly refracting liquid. It smells like turpentine, tastes bitter, is insoluble in water, but dissolves readily in alcohol and ether; does not liquefy at -12° . Sp. gr. = 1.540.

It is not volatile. In its chemical relations, it resembles chloride of potassium.

Stibethylum, SbAc_4 .—Known as yet only in the form of iodide, which is obtained by adding iodide of ethyl to stibethyl. The iodide crystallizes in long beautiful needles, which are easily soluble in water and alcohol.

Stibamyl, SbAm_3 .—Clear, colourless liquid, which fumes in the air, but without taking fire. It forms compounds analogous to those of stibethyl, but they are all liquid and insoluble in water.

Bismethyl or *Bismuthide* of *Ethyl*:* BiAc_3 . Bismethyl is obtained in the same manner as stibethyl, bismuthide of potassium being substituted for the antimonide. Forms a slightly yellow, very mobile liquid, of sp. gr. 1.80, which can only be distilled with water. Has a disagreeable odour, like that of stibethyl, and produces, even if only traces of it are inhaled, an extremely unpleasant, burning sensation on the tongue. When exposed to the air, it emits dense vapours, and takes fire, diffusing a thick yellow smoke of oxide of bismuth. With oxygen, the halogens, and sulphur, it combines in the same proportions as stibethyl; but the resulting compounds are less permanent; for instance, when an alcoholic solution of iodide of bismethyl is left to stand for awhile, pure iodide of bismethyl separates out. Bismethyl when heated alone, is decomposed, with separation of bismuth and evolution of gaseous products. If suddenly exposed to a high temperature, it explodes with great violence.

Observations on Telluric Ethyl, or Telluride of Ethyl.

By W. Mallet.†

Wöhler, in his notice upon telluride of ethyl,‡ states that it is dissolved by nitric acid with evolution of nitric oxide, and that on adding hydrochloric acid to this solution, a heavy colourless liquid is precipitated in oily drops. The nature of this liquid was not further investigated.

Mallet, in pursuing this subject, has found that telluride of ethyl

* Löwig. Grundriss der Organischen Chemie. S. 386.

† Ann. Ch. Pharm. LXXIX, 223.

‡ Ibid. XXXV, 112.

behaves like an organic radical. The substance was prepared by Wöhler's process, viz., by distilling a concentrated solution of sulphovinate of baryta with telluride of potassium. Its vapour has an intense yellow colour.

In attempting to prepare a *telluric mercaptan*, $C_4H_6Te_2$, by dissolving in water a mixture of sulphovinate of baryta and telluride of potassium in a flask previously filled with hydrogen gas, then saturating the solution with telluretted hydrogen, and distilling, the only product at first obtained was monotelluride of ethyl, C_4H_5Te . But on continuing the distillation at a stronger heat, another liquid passed over with the water, distinguished from the former by much greater density, higher boiling-point, and an intense red colour, so that even in small masses, it appeared black and opaque, like bromine; it had an offensive odour. Analysis showed it consisted of *bitelluride* of ethyl, $C_4H_5Te_2$.

Nitrate of Telluric Ethyl.— $C_4H_5TeO \cdot NO^5$.—When a solution of monotelluride of ethyl in nitric acid is evaporated to dryness at a gentle heat, there remains a white, crystalline mass, which dissolves perfectly in water, and burns away like gunpowder when heated. Alkalies produce no precipitate in solutions of this salt, because the base C_4H_5TeO , is soluble in water. Sulphurous acid, on the contrary, immediately reduces the radical, which separates in dark-red drops. Sulphuretted hydrogen produces an orange-coloured precipitate, which, on heating the liquid, fuses into heavy black drops, doubtless consisting of the sulphur-compound of telluride of ethyl = C_4H_5TeS .

Chloride of Telluric Ethyl, C_4H_5TeCl , separates in the form of a colourless oil, on the addition of hydrochloric acid to a solution of telluride of ethyl in nitric acid. At first, the liquid becomes milk-white, but the compound soon collects in large, transparent drops, which sink in the water. It has an offensive odour. It may be distilled without decomposition, but its boiling-point appears to be very high, for when distilled with water, it passes over very slowly. By analysis, it was found to contain 50.55 per cent of tellurium, and 27.07 of chlorine, the calculated numbers being 49.81 Te and 27.63 Cl.

Oxide of Telluric Ethyl, C_4H_5TeO , is formed by treating the chloride immersed in water with recently precipitated oxide of silver. The liquid becomes warm, and chloride of silver is formed. The filtered liquid is a solution of the oxide of telluric ethyl in water; and on evaporation at a gentle heat, the oxide remains in the form of a colourless, highly crystalline mass. The aqueous solution exhibits an alkaline reaction with turmeric. The oxide, when heated in a tube, is decomposed, with separation of metallic tellurium, and formation of an oil having an offensive odour. When heated in the air, it burns with a blue flame like tellurium. Sulphurous acid decomposes the solution,

and separates the telluride of ethyl in red drops. Hydrochloric acid throws down the chloride in colourless drops.

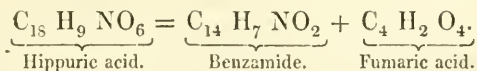
The oxide is likewise formed by direct oxidation of an alcoholic solution of telluric ethyl in the air; the process is, however, too slow to be practically available. It is likewise obtained in the form of a sulphate, by treating telluride of ethyl with peroxide of lead and dilute sulphuric acid.

The solution of the oxide gives a yellow precipitate with chloride of platinum, and white with corrosive sublimate. When it is mixed with chloride of ammonium—the solutions not being too dilute—ammonia is set free, and after a short time, a salt separates in small crystals arranged in stellate groups, and having exactly the form and the angles of gypsum. This salt dissolves readily in hot water, and crystallizes out again unaltered on cooling. By analysis, it was found to contain 26·73 per cent of tellurium and 15·45 of chlorine, numbers which appear to agree only with the formula $C_4H_5TeCl + 2NH^4Cl$, and with the supposition, that in the decomposition with the silver-salt, only one-third of the chlorine is separated. But whether this is really the case, and what other compound is thereby formed, the author was unable to decide for want of material.

Examination of certain products obtained from Hippuric Acid.

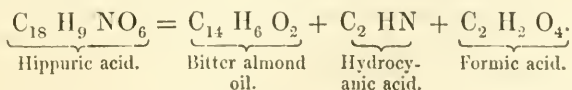
By N. Socoloff and A. Strecker.*

There are few organic acids whose rational constitution has given rise to so many different opinions as that of hippuric acid. From the decomposition which this acid undergoes by the action of peroxide of lead, whereby it is converted into benzamide and carbonic acid, Fehling regarded it as a compound of benzamide with an acid (fumaric acid) convertible into carbonic acid by addition of oxygen: thus



This view of the decomposition, however, is not quite satisfactory, inasmuch as fumaric acid is not altered by boiling with water and peroxide of lead.

Pelouze regarded the composition of hippuric acid as follows:



* Ann. Ch. Pharm. LXXX, 17.

This view of its constitution is based principally on the evolution of hydrocyanic acid in the dry distillation of hippuric acid, and on the formation of benzoic acid, carbonic acid, and ammonia, on treating hippuric acid with sulphuric acid and peroxide of manganese.

Since, however, the acids composed of formic acid conjugated with aldehydes (lactic, mandelic acid, &c.) give up the aldehydes in the free state under similar circumstances, it follows that the constitution of hippuric acid assigned by Pelouze, is not in accordance with its decomposition.

After Dessaignes had found that hippuric acid is resolved, by the action of strong boiling acids and alkalies, into benzoic acid and glycolic acid, the majority of chemists were inclined to regard it as a conjugated compound of those two substances. But upon that supposition, as correctly observed by Berzelius, the transformation effected by peroxide of lead becomes unintelligible.

These different views of the constitution of hippuric acid suppose that there exists in this acid a group of atoms containing 14 eqivs. of carbon—that is to say a benzoyl group—together with a second group which contains 4 eqivs. carbon, and, under particular circumstances, may be resolved into two other bodies, each containing 2 eqivs. of carbon.

Since, however, the nitrogen may be transferred to the one or the other group of atoms, according to the action to which the hippuric acid is subjected, it appears more conformable with the behaviour of this acid, to regard the nitrogen as more intimately combined, not with either of these groups of atoms alone, but with the conjugated compound resulting from their union, and consequently to regard hippuric acid as an amide of the conjugated acid, $C_{18}H_8O_8$. This acid cannot well be separated by the action of alkalis or acids on the amidogen-acid, because the conjugated acid thereby suffers decomposition. Nitrous acid, however, separates the non-nitrogenous acid (as previously shown by one of the authors of this paper*), acting in fact in this instance as it does upon other amidogen-compounds. To this acid, whose composition is expressed by the formula just stated, the authors give the name of *Benzoglycolic acid*. The present memoir contains a more particular examination of this acid, together with its salts and products of decomposition.

The hippuric acid used in the preparation was obtained from horses' urine, by Gregory's process somewhat modified, viz., by boiling the urine for a short time with milk of lime, then straining the liquid, carefully neutralizing it with hydrochloric acid, concentrating at a boiling heat, and adding hydrochloric acid after cooling. The hippuric acid thus obtained, after being washed with cold water, was nearly white, with only a faint tinge of red.

* Ann. Ch. Pharm. LXVIII, 54.

Hippuric acid does not act upon an aqueous solution of nitrate of potash, neither is any action produced by dissolving it in strong sulphuric acid, and passing nitrous acid (evolved from nitric acid and starch) through the solution. But when nitrous acid is passed into a warm aqueous solution of hippuric acid in which powdered hippuric acid is suspended, decomposition takes place, attended with evolution of nitrogen. This method, however, is not advantageous, because a large portion of the nitrous acid is resolved into nitric oxide and nitric acid, which latter substance decomposes the new acid at the temperature of the liquid. The following method was found to yield the best results.

The hippuric acid, dried in the air and pulverized, was mixed in a mortar with a quantity of commercial nitric acid, sufficient to form it into a thin paste. The mass was then put into a tall glass cylinder (so as to form a long column of liquid), and nitric oxide gas (evolved from copper and nitric acid) passed through it at a moderate rate. As a strong effervescence takes place, the cylinder must not be more than half filled with the liquid. The hippuric acid then dissolves, and bubbles of nitrogen are evolved from the liquid. The termination of the action cannot be very accurately observed, but the passage of the gas may be continued till the liquid assumes a distinct green colour; an excess of nitric oxide is not injurious, but rather beneficial, inasmuch as it removes a portion of the solvent. The operation is complete in five or six hours, and does not require the application of heat. Part of the benzoglycolic acid separates from the solution even during the passage of the gas, but the greater portion is precipitated on the addition of water. The liquid, which has become warm, is then left to cool, and filtered through a paper filter doubled at the apex, and the benzoglycolic acid is washed on the filter with water as cold as can be obtained.

The benzoglycolic acid thus produced is impure and has a slight yellow colour. It is purified by converting it into a lime-salt, and decomposing this salt with hydrochloric acid. For this purpose, the crude acid is suspended in water, and neutralized with milk of lime. It then solidifies in a few minutes to a solid mass; but on the application of heat, the lime-salt dissolves, and separates out from the filtered liquid on cooling, in very long, fine needles, which are yellow at first, from enclosed mother-liquor, but after washing with cold water, and strong pressure, become perfectly colourless. The nitric acid diluted with water retains a considerable quantity of benzoglycolic acid in solution. This portion may be separated by neutralizing with carbonate of potash; concentrating at a boiling heat; decanting the liquid from the nitrate of potash which separates out on cooling; concentrating again; and mixing this last mother-liquid, which contains nearly all the benzoglycolate of potash, with strong nitric acid. The crystals which separate consist of benzoglycolic acid generally

contaminated with benzoic acid, to remove which, one half of the mixture is neutralized with milk of lime, the other half then added, and the mixture evaporated to dryness. The benzoglycolic acid then remains in combination with the lime, while the benzoic acid is set free and may be dissolved out by ether in Payen's extraction-apparatus. The benzoglycolate of lime which remains is perfectly pure and white.

To obtain the pure acid, the lime-salt is dissolved in water, and mixed in the cold with hydrochloric acid, whereupon the acid separates in the form of a light, perfectly white powder. Larger crystals are obtained by dissolving the lime-salt in alcohol, adding sulphuric acid, filtering, and leaving the liquid to evaporate freely. The acid then separates in tolerably large, colourless prisms, with dihedral angles of $37^{\circ} 40'$ and $142^{\circ} 20'$, and flattened into thin tables by the excessive development of two of the prismatic faces.

The crystals separated from the alcoholic solution lost no weight at 100° ; their analysis yielded the following results:

	Calculation.		Mean of experiments.
C ₁₈	108	60·00	60·09
H ₈	8	4·44	4·66
O ₈	64	35·56	35·25
C ₁₈ H ₈ O ₈	180	100·00	100·00

Benzoglycolic acid is very sparingly soluble in cold water, but dissolves more readily in hot water, by which also it is gradually decomposed. Heated with a quantity of water not sufficient to dissolve it, it fuses into oily drops. It dissolves readily in alcohol and ether. When heated on platinum-foil, it fuses, and solidifies again in the crystalline state in cooling. When strongly heated, it gives off vapours which excite coughing and smell of benzoic acid, leaving a coaly residue which easily burns away at a red heat.

SALTS OF BENZOGLYCOLIC ACID.

These salts are mostly soluble in water, and many of them also in alcohol. They have a neutral reaction and a faint but peculiar taste. From the aqueous solutions, most of the stronger acids, and even acetic acid, throw down benzoglycolic acid in small crystals.

Benzoglycolate of potash is obtained by exactly saturating the acid with carbonate of potash, or by decomposing the lime-salt with carbonate of potash. It dissolves readily in water and alcohol, and crystallizes with difficulty and indistinctly. From a solution saturated while hot, it crystallizes, on cooling, in extremely thin and very broad tables. By spontaneous evaporation, it is obtained in cauliflower-like masses.

Benzoglycolate of soda crystallizes much more readily than the potash-salt, and separates on cooling from a hot saturated solution in tolerably large, rhombic tables, whose composition is: $\text{NaO} \cdot \text{C}_{18} \text{H}_7 \text{O}_7 + 6\text{Aq.}$ The whole of the water is given off at 100° .

The ammonia-salt is prepared like the potash-salt; it gives off ammonia when evaporated.

Benzoglycolate of lime is obtained, as already described, by saturating the free acid with milk of lime. It possesses in the highest degree, the property of forming super-saturated solutions, so that sometimes, perfectly cold solutions from which part of the salt has already crystallized out, become turbid while being strained through a fine cloth, and in a few minutes solidify to a thick jelly. If the liquid be then filtered, the mother-liquor generally solidifies again after a while. The salt forms fine silky needles grouped like Wavellite. The crystals are permanent in the air, lose no weight at 100° , but give off 1 atom water at 120°C. Their formula is $\text{CaO} \cdot \text{C}_{18} \text{H}_7 \text{O}_7 + \text{Aq.}$ 100 parts of water dissolved 2.36 parts of the salt at 11°C. , and 13.26 parts at 100° .

Benzoglycolate of baryta crystallizes like the lime-salt in silky crystals. It contains 2 atoms water of crystallization which it gives off at 100° .

Benzoglycolate of magnesia is obtained by mixing the boiling solutions of benzo-glycolate of lime and sulphate of magnesia, and exhausting the solidified mass with absolute alcohol. The salt crystallizes by evaporation and cooling in extremely fine soft needles, and consequently forms a very bulky mass.

Benzoglycolate of ferric oxide.—When solution of benzo-glycolate of lime is mixed with sesquichloride of iron, a bulky non-crystalline flesh-coloured precipitate is obtained, which becomes darker on the surface when exposed to the air. It is perfectly insoluble in water. When dried in the air, it contains 28 atoms water which are all driven off at 100° . The formula is: $2 \text{Fe}_2 \text{O}_3 \cdot 3(\text{C}_{18} \text{H}_7 \text{O}_7) + 28 \text{Aq.}$

Benzoglycolate of zinc is obtained on mixing the lime-salt with chloride of zinc, in long, thin, colourless needles, grouped in stellate masses. The crystals contain $\text{ZnO} \cdot \text{C}_{18} \text{H}_7 \text{O}_7 + 4 \text{Aq.}$; the whole of the water escapes at 100° .

Benzoglycolate of copper is obtained by mixing a boiling solution of the lime-salt with nitrate of copper. It crystallizes in beautiful blue rhombic tables, very sparingly soluble in cold water, somewhat more soluble in hot water. On heating the crystals with a quantity of water not sufficient to dissolve them, the undissolved portion is converted into a green powder, probably consisting of the anhydrous salt. At 100° the crystals become green and opaque, but the faces retain their lustre.

Lead-salts.—*a. Sesquibasic.*—A cold solution of benzo-glycolate of lime is precipitated in curdy flakes by neutral acetate of lead. The

precipitate is sparingly soluble in cold water; when heated with water, it first melts, then dissolves completely, and separates again on cooling. The first deposit is amorphous, but after cooling the lead-salt separates in crystals. On digesting the original curdy precipitate in a large quantity of cold water, filtering, and leaving the solution to spontaneous evaporation, the salt was obtained after a few days in crystals united in dense, hemispherical masses. These crystals contain 3 atoms water which are given off at 100° , the anhydrous salt fusing at the same time. Their composition is: $3\text{PbO} \cdot 2(\text{C}_{18}\text{H}_7\text{O}_7) + 3\text{Aq}$.

β. Monobasic.—The mother-liquor from which the preceding salt had separated, yielded after long standing, a quantity of thin, short, soft needles, grouped in stellate masses. These crystals were easily separated from the former salt by levigation. They are anhydrous, their formula being, $\text{PbO} \cdot \text{C}_{18}\text{H}_7\text{O}_7$.

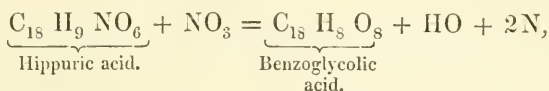
γ. Sexbasic.—A boiling solution of the lime-salt, mixed with neutral acetate of lead, yields an amorphous white precipitate, which is almost wholly soluble in acetic acid: it is a mixture of several basic salts. But when a cold solution of benzoglycolate of lime is mixed with basic acetate of lead, a flocculent precipitate is formed which does not fuse when boiled in water, and is but very slightly soluble in water. The precipitate, after partial washing, was immersed in cold water, the solution filtered, and then left to stand. In a few days, crystals were separated, having the appearance of the neutral salt, and mixed with a small quantity of carbonate of lead from which they were separated by levigation. Their composition was found to be: $6\text{PbO} \cdot \text{C}_{18}\text{H}_7\text{O}_7 + 2\text{HO}$; the water was given off at 100° . The lead precipitates obtained by direct precipitation are always mixtures of several basic lead-salts.

Benzoglycolate of silver.—When a neutral solution of the lime-salt is mixed with nitrate of silver, the resulting precipitate washed with a small quantity of cold water, then dissolved in boiling water, and the solution left to cool, fine white microscopic crystals are obtained, which soon blacken when exposed to daylight. When prepared by artificial light, the salt is perfectly white. Its formula is: $\text{AgO} \cdot \text{C}_{18}\text{H}_7\text{O}_7$.

Benzoglycolic ether.—An alcoholic solution of benzoglycolic acid left to stand for some time, evolves a peculiar odour, probably arising from the formation of a compound ether. But on passing dry hydrochloric acid into an alcoholic solution of the lime-salt, in which a quantity of the solid salt was suspended, and afterwards adding water, an oily liquid separated which was found to consist almost wholly of benzoic ether; the benzoglycolic acid therefore had been decomposed by the hydrochloric acid.

From the preceding description of the salts of benzoglycolic acid,

it appears that this acid, $\text{HO} \cdot \text{C}_{18} \text{H}_7 \text{O}_7$ contains 1 equiv. of water which can be replaced by metallic oxides, and moreover saturates the same quantity of base as the hippuric acid from which it is produced. Its production from hippuric acid is expressed by the equation :



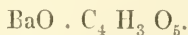
and is therefore perfectly analogous to the formation of other acids from their amides. The saturating power is, however, remarkable ; for in most cases the amidogen-acid saturates 1 equiv. of base less than the free acid. Nevertheless the case of benzoglycolic acid is not quite peculiar ; for the same relation is observed between aspartic acid and malic acid produced from it by a reaction similar to the above,* also between salicylic acid and its amide.

This saturating power shows a remarkable difference between the ordinary amides and amidogen-acids, and the bodies which stand nearest to this group, viz., hippuric acid, alanin, anthranilic acid, &c. though both exhibit the same deportment towards nitrous acid.

PRODUCTS OF DECOMPOSITION.

It has been already mentioned that benzoglycolic acid is generally decomposed by boiling its aqueous solution with water ; its salts are also decomposed in the same manner, but much more slowly. The acid is much more quickly decomposed when heated with dilute acids, benzoic acid volatilizing with the watery vapours, and a new acid remaining in solution.

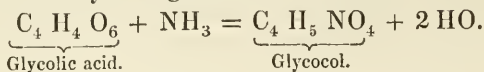
To examine this new product, benzoglycolic acid was boiled for some days with water to which a small quantity of sulphuric acid was added, the water being replaced as it evaporated. A large quantity of benzoic acid volatilized with the watery vapour, and on concentrating to a small bulk and leaving the solution to cool, a further quantity of that acid crystallized out. The mother-liquor was neutralized with carbonate of baryta, filtered from the precipitated sulphate, evaporated to a syrupy consistence, and left to stand for several days. A salt then separated in white hard crystalline crusts, which gave by analysis results nearly agreeing with the formula :



The acid contained in this salt, which in the anhydrous state has the formula $\text{C}_4 \text{H}_3 \text{O}_5$, or in the hydrated state, $\text{C}_4 \text{H}_4 \text{O}_6$, agrees

* Ann. Ch. Pharm. LXXV, 296

with that to which Laurent* assigns the name of *Glycolic acid*, because glyecol may be regarded as its amide.



This acid, however, had not been previously prepared.

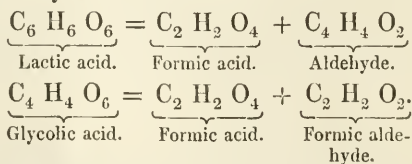
To separate the acid from its baryta-salt, the aqueous solution of that salt is treated with dilute sulphuric acid, filtered, and the filtrate evaporated over the water-bath. The syrupy residue dissolves completely in ether, and on evaporating the ether, the acid is again obtained in the form of a thin syrup which refuses to crystallize.

Glycolic acid is miscible in all proportions with water, alcohol and ether. It has a strongly sour taste, and does not give a precipitate with any metallic salt. In all its properties it bears the closest resemblance to lactic acid; indeed, the only reaction which distinguishes the two is, that when a solution of glycolic acid is mixed with acetate of lead, and ammonia added, a white flocculent precipitate is produced, whereas lactic acid similarly treated remains clear.

Glycolate of zinc was obtained by heating the diluted aqueous acid with carbonate of zinc, then filtering and evaporating. As the liquid cooled, crystalline crusts separated out, having a strong resemblance to lactate of zinc. The individual crystals are small, colourless, transparent prisms, arranged in stellate groups round numerous points. The formula of the salt is $\text{ZnO} \cdot \text{C}_4 \text{H}_3 \text{O}_5 + 2 \text{Aq.}$ The water is given off at 100° . The salt is insoluble in alcohol, difficultly soluble in cold water, more readily in hot water. 1 part of the anhydrous salt dissolves in 33 parts of water at 20°C.

Glycolate of silver appears to be a very instable salt. The solution obtained by decomposing glycolate of baryta with sulphate of silver and filtering, decomposed and deposited a black insoluble substance, even when evaporated in vacuo over sulphuric acid. The addition of alcohol or of ether to the solution produced no precipitate.

Glycolic acid, as already observed, exhibits an extremely close resemblance to lactic acid. If the latter may be regarded as a conjugated compound of formic acid with common aldehyde, glycolic acid ought perhaps to be considered as a corresponding compound containing the aldehyde of formic acid:

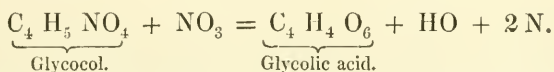


Formic aldehyde is probably obtained in the dry distillation of glycolic acid, or on treating that substance with oxidizing agents.

* Ann. Ch. Phys. [3], XXIII, 112.

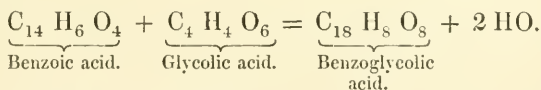
When hippuric acid is treated with peroxide of lead, an extremely pungent odour is evolved ; and Schwartz observed that the aqueous distillate gives the reactions of the aldehydes with nitrate of silver. It seems therefore probable that these phenomena are produced by the aldehyde of formic acid, which, being gaseous at ordinary temperatures, has hitherto escaped notice.

Glycolic acid is also produced by the action of nitrous acid upon glycol. This substance, in the state of aqueous solution, is decomposed by nitrous acid, with evolution of nitrogen. If the solution be then evaporated, the glycol becomes oxidated by the nitric acid produced from the nitrous acid, and crystals of oxalic acid are found in the residue. If on the other hand, the solution of glycol, after treatment with nitrous acid, be agitated with ether, the ether extracts the glycolic acid from the aqueous solution ; and, on evaporating the ether, the glycolic acid remains in the form of a syrupy liquid, similar in properties to the acid obtained from benzoglycolic acid. The preparation from the last-mentioned acid is however the easier method of the two. The formation of glycolic acid from glycol is expressed by the equation :



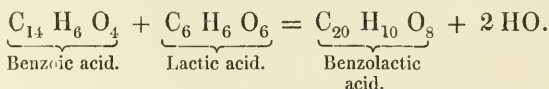
The same results are therefore obtained whether hippuric acid be first treated with nitrous acid and the benzoglycolic acid afterwards decomposed by boiling with acids, or the hippuric acid first resolved into benzoic acid and glycol, and the latter subsequently treated with nitrous acid.

It appears, from the facts already stated, that benzoglycolic acid is easily resolved into benzoic and glycolic acids, and there are grounds for supposing that it may be reproduced by the union of its constituents : thus



The authors were prevented by want of material from confirming this theory by experiment, but they obtained an analogous result with lactic acid. A mixture of lactic and benzoic acid was heated to 180° C., and kept at that temperature as long as aqueous vapour continued to escape. The residue solidified, on cooling, in a resinous mass which was dissolved in water with addition of potash. To the warm solution, dilute sulphuric was added, till benzoic acid no longer crystallized out on cooling, and the crystals obtained exhibited a different form. The separated acid was then removed by filtration, and the filtrate mixed in the cold with dilute sulphuric acid. An abundant precipi-

tate was produced, which first fused on being boiled with water, then dissolved in a large quantity of water, and on cooling separated partly in drops, partly in crystals. This acid was dissolved in ether and recrystallized by evaporation, then neutralized with ammonia, and precipitated by silver-solution. The precipitate yielded 39.7 per cent of oxide of silver, a result nearly agreeing with the formula, $\text{AgO} \cdot \text{C}_{20} \text{H}_9 \text{O}_7$, which requires 38.5 per cent. The excess arose from the presence of benzoic acid. The formation of the new acid, which may be called *Benzolactic acid*, is expressed by the following equation:



On a new method of separating substances possessing very similar properties.

By W. Heintz.*

This method is founded on an extension of the principle applied by Liebig† to the separation of certain volatile acids of the adipic series. It consists in adding to the mixture a substance capable of combining with all the original substances which compose it, but in quantity less than sufficient to saturate the whole, and subjecting the mixture thus treated to distillation, the action of solvents, &c.

In order that a separation may be effected in this manner, it is necessary; first, that the substance added possess a decided chemical affinity for the substances contained in the mixture, and that the resulting compounds differ so much in their properties from the original substances, as to be easily separated from them by the action of solvents or by distillation; secondly, that the substance added possess different degrees of affinity for the substances contained in the mixture. If this latter condition be not fulfilled, no separation can take place. Experience shows, however, that perfect equality of affinity of two substances for a third exists only at particular temperatures; hence, by varying the temperature, the desired inequality may always be attained.

The particular mode of effecting the separation will of course vary with the nature of the substances present. The following is the process which the author has adopted with mixtures of the non-volatile fatty acids, stearic, margaric acid, &c. The separation of these bodies is well known to be a matter of great difficulty, on account of the close resemblance existing between them and all their corresponding compounds.

* Pogg. Ann. LXXXIV, 221.

† Ann. Chem. Pharm. LXXI, 325.

The fatty acids are dissolved in a quantity of boiling alcohol, sufficient to retain the whole in solution when the temperature is lowered to 0°C ., and a boiling alcoholic solution of crystallized acetate of lead is added drop by drop, in quantity sufficient to saturate about one-half of the acids with oxide of lead. In most cases, as with stearic, margaric, ethalic, and palmitic acid, the quantity of sugar of lead required for this purpose amounts to about one-third of the weight of the fatty acids. If the proper quantity of alcohol has been added to the mixture, the alcoholic solution remains clear as long as it is kept boiling, but becomes turbid on the slightest reduction of temperature; and as the liquid cools, the whole of the oxide of lead is precipitated in combination with half the fatty acid. The formation of a precipitate at the boiling temperature shows that the quantity of alcohol used is insufficient; in that case it is best to add a few drops of acetic acid, by which the separated lead-salt is readily dissolved. The liquid is filtered when cold, and the precipitate washed till the filtrate is no longer clouded by water; the washing is very expeditious.

The lead-salt, saturated with alcohol, is then removed from the filter and boiled for a short time with hydrochloric acid. Chloride of lead then separates completely, and sinks rapidly to the bottom, while the fatty acid remains dissolved in the alcohol. The solution, however, still contains a portion of the ethyl-compound of the fatty acid. It is therefore super-saturated with caustic potash, and boiled till the ethyl-compound is completely decomposed; after which, water is added, and the greater part of the alcohol expelled by evaporation. Lastly, the acid is separated from the potash-salt by boiling with hydrochloric acid.

To separate the acid dissolved in the alcoholic solution, acetate of lead also dissolved in alcohol is added in slight excess, the precipitate collected on a filter, and treated in the manner already described.

As the separation thus effected is not complete, the lead-precipitates, instead of being washed, may be squeezed by a powerful press, and then decomposed by boiling with very dilute hydrochloric acid, or better, by treating them with alcohol and hydrochloric acid and afterwards with hydrate of potash and hydrochloric acid. The melting points of both portions of the acid are then to be determined. If they are nearly equal, and the two portions are otherwise not essentially different in their physical properties, it may safely be concluded that the substance under examination was not a mixture, but consisted essentially of *one* definite compound, possibly contaminated by a small quantity of another. In this case, the two portions may be united, and purified by one or two recrystallizations from alcohol. If, on the contrary, the melting points and other physical characters of the two acids differ considerably, the process must be repeated upon each, and the same treatment continued till the melting

points, &c. of the portions last separated are nearly equal. These last portions are then to be united and crystallized once or twice from alcohol. This process will serve likewise to separate a mixture of three or more acids, provided that not only the extreme portions, those namely which contain the strongest and weakest acids, but likewise the intermediate portions, are subjected to the same treatment.

If any of the acids thus separated assume a well-defined crystalline structure, when it passes from the liquid to the solid state, it will for the most part be unnecessary to subject it any further to the preceding treatment; one or two crystallizations from alcohol will yield it in a state of perfect purity.

When it is thought that a pure acid has been obtained in the manner above described, it is best to subject it once more to the same treatment, in order to make sure of its purity.

By pursuing this method the author has found:

1. That the so-called pure *stearine* which melts at 61° or 62° C., is a mixture of two or more fats containing glycerine.

2. That the substance commonly regarded as pure *cetine* is a mixture of at least two fats containing ethyl. It does not melt constantly at 49° or 49.5° C.; but by recrystallization from the ethereal solution, its melting point may be raised to 53.5° .

Another result of the author's experiments is, that spermaceti may be easily saponified by a boiling solution of caustic potash.

On the composition of Human Fat.

By W. Heintz.

The investigations of Chevreul into the composition of human fat showed, that it consists of a liquid fat, viz., oleine, and a solid fat, to which Chevreul gave the name of *stearine*, but which, as it yields margaric acid by saponification, must really consist of margarine. Subsequently Lerch has shown that the volatile portion of the fat contains caprylic acid; and Brücke, has found that the solid portion does not yield pure margaric acid by saponification, but an acid which melts at 56° , and does not crystallize like margaric acid. Hence it would appear that human fat contains besides margarine, another solid fat which by saponification yields another fatty acid, not separable from margaric acid by crystallization.

After various fruitless attempts to obtain the pure margarine by exposing the fat to a very low temperature, and crystallizing the solid portion from a solution in ether, Heintz resorted to the method of

saponifying the fat with caustic potash; and as the separation of the oleic acid thus produced from the margaric and other solid acids, by the usual method of converting them into lead-salts and digesting in ether, is very tedious and involves a very large consumption of ether, he finally adopted the method of separating the fatty acids from the mixed potash-salts by means of hydrochloric acid, and subjecting the liquid portion to the action of powerful press,—then dissolving the resulting hardish mass in a third of its weight of alcohol, leaving it to solidify at as low a temperature as possible, pressing again, and repeating these operations till every trace of oleic acid was removed from the solid acids—a point which was generally attained at the third pressure. The mixture of solid fatty acids was then treated by the method described in the preceding paper, and was found to contain four different fats. The liquid portion was found to consist principally of oleine. The general results of the investigation are as follows :

1. Human fat does not consist, as formerly supposed, merely of oleine and margarine, but is a mixture of at least *six* different fats.

2. The first of these fats is present in very small quantity only, but appears, from an analysis of the fatty acid obtained from it, to be identical with *Stearophanine*, the substance which Francis discovered in the berries of *Cocculus indicus*. The composition and properties of this acid, so far as they have been studied, agree with those of stearophanic acid, the formula of which is $C_{36} H_{36} O_4$.

3. The second fat is a new substance, to which the author gives the name of *Anthropine*. The fatty acid obtained from it by saponification, is distinguished by its strong tendency to crystallize. It separates from the alcoholic solution, and likewise solidifies from a state of fusion, in broad, shining laminae. Its composition appears to agree with the formula, $C_{34} H_{32} O_4$; but further experiments are necessary to establish this result.

4. The third fat is *Margarine*, which yields margaric acid by saponification.

5. The fourth substance contained in this solid portion of the fat is *Palmitine*, which yields palmitic acid by saponification; it appears to be the most abundant of the four.

6. The palmitic obtained from human fat is identical with that which is formed by the action of fused potash upon oleic acid, and to which Varrentrapp gave the name of *Olidic acid*.

7. The liquid portion of human fat is composed essentially of *Oleine*; but it likewise contains a small quantity of another fat, which, by saponification, yields an acid whose baryta-salt differs from oleate of baryta, not only by its physical properties, but likewise by the quantity of baryta contained in it, viz., from 27 to 28 per cent. This baryta-salt is much less soluble in alcohol than oleate of baryta, but

is converted into a tenacious liquid mass at a much lower temperature than the latter, and is more soluble in ether.

8. It has been before observed that when human fat is exposed in water to a temperature varying above and below 0°C ., a liquid fat may be separated from the solid portion; and this liquid fat, if left to itself till the next winter, and again exposed for some time to the same low temperature, yields another tolerably large portion of solid fat. If this be again separated by pressure, and the liquid fat once more left to itself, a still further portion of solid fat will separate in the following winter. Now, when the solid fat thus separated in the second or third winter, is dissolved in hot alcohol, filtered when the temperature of the liquid has fallen to 30°C ., and then left to cool further, a substance separates out, which, after recrystallization from alcohol, dissolves readily in a dilute aqueous solution of carbonate of soda at a boiling heat, and therefore consists of a fatty acid. It appears then that human fat when left to itself, undergoes a gradual decomposition, by which the glycerine is destroyed, and the fatty acid separated, a kind of decomposition long known to take place in fats which yield easily volatile acids, for instance, in butter when it becomes rancid.

On a new compound of Mercury.

By Sobrero and Selmi.*

When an alcoholic solution of potash is added to a solution of corrosive sublimate in alcohol of the strength of 40° , a yellow precipitate is obtained, consisting, not of protoxide of mercury, but of a compound of mercury with carbon, hydrogen, and oxygen. This precipitate is amorphous and insoluble in water and alcohol; it may be washed to free it from excess of potash and chloride of potassium.

In preparing this substance, it is best to employ a temperature of about 50°C . It is stable at ordinary temperatures, and sustains without decomposition a temperature not far from 200°C .; when more strongly heated, it assumes an orange colour, and decomposes suddenly and with violent detonation, being completely resolved into gaseous products without residue. That the compound may possess the property of detonating in the manner just described, the preparation must be conducted with attention to the circumstances above-mentioned; if the preparation be made at a lower temperature, or an insufficient quantity of potash added, the resulting precipitate detonates less strongly and leaves a residue of red oxide of mercury.

* *Compt. Rend.* XXXIII, 67; *Ann. Ch. Pharm.* LXXX, 108.

When exposed to direct light, this body blackens very rapidly. If heated in a glass tube while still moist, it decomposes with less violence and leaves metallic mercury, water, and acetic acid.

This substance dissolves completely in hydrochloric acid, even in the cold, undergoing decomposition at the same time, and yielding a volatile substance, which has a pungent, irritating, and quite peculiar odour, and acts upon the throat in a similar manner to hydrocyanic acid. This volatile substance may be obtained, mixed with hydrochloric acid, by distilling the mixture. The authors have not yet analyzed this substance; but they observe that, on the addition of nitrate of silver, there is formed, besides the precipitate of chloride of silver, a soluble compound which yields very beautiful, transparent crystals.

Sulphuric acid dissolves this compound of mercury, forming crystalline products. Nitric acid likewise dissolves it, and the solution yields with caustic potash, an ash-grey precipitate, which when treated with hydrochloric acid, gives off a volatile substance having the same odour as that produced when the original mercury-compound is acted upon by hydrochloric acid. Acetic acid dissolves the mercury-compound almost completely, and the solution, when evaporated, yields a crystalline substance.

The new mercury-compound boiled with a solution of sal-ammoniac, drives out the ammonia, forming, at the same time, a soluble, crystallizable body. A crystalline compound is likewise obtained by boiling that substance with a solution of corrosive sublimate.

Although the authors have hitherto been unable to obtain any determinate data for the composition of this remarkable compound, they are nevertheless able to assert that it consists of mercury, carbon, hydrogen, and oxygen, and that the last three elements are not in the proportion required to form alcohol, the quantity of hydrogen being much too small; moreover, that the compound acts like a very strong base, and combines, not only with sulphuric, nitric, and acetic acid, but likewise with many other acids.

In the course of the experiments made with this substance, other mercury-compounds were obtained having more or less relation to it. Thus a substance different from the preceding is obtained by slowly adding a very weak solution of potash to a boiling solution of corrosive sublimate, &c.

On dissolving mercury in nitric acid, expelling all nitrous products by continued boiling, and adding the solution to alcohol of 36° , in the same proportion as for the preparation of fulminating silver, no immediate action takes place, provided the mixture be made at a temperature below 100° ; but if the temperature be raised to 100° , a white crystalline compound is instantly formed, and its formation continues, even when heat is no longer applied. This reaction, not-

withstanding the rapidity with which it goes on, is not attended with evolution of gas. The precipitate contains mercuric oxide, nitric acid, carbon and hydrogen; when treated with hydrochloric acid, it yields a volatile product having the peculiar odour mentioned in a former part of this paper.

It may be confidently predicted that compounds analogous to the above will be obtained by similar processes, in which amylic or methylic alcohol is used instead of common alcohol, and other metals, such as silver, instead of mercury.

On Ethylo-mercuric Nitrate.

By Ch. Gerhardt.*

Gerhardt did not succeed in preparing the yellow detonating oxide of mercury by the process described by Sobrero and Selmi;† he is moreover of opinion that this process is not likely to yield a product sufficiently pure for analysis. On the other hand, he readily obtained the peculiar salt produced on mixing alcohol with mercuric nitrate. This salt has a very remarkable constitution, as will be seen by the following observations.

Mercurous nitrate has no action on alcohol. When an acid solution of that salt is mixed with alcohol of 36°, and the mixture heated, basic mercurous nitrate separates out in white crystals, which do not contain organic matter.

When alcohol is mixed with a very concentrated solution of mercuric nitrate, there is formed in the cold, an amorphous white precipitate of basic mercuric nitrate; if the mercury-salt contains excess of nitric acid, no precipitate is formed in the cold. On heating the liquid, however, a white crystalline precipitate separates, even before the liquid begins to boil, and its formation continues, without further application of heat. This is the salt obtained by Sobrero and Selmi. When examined by the microscope, it exhibits a highly characteristic form, consisting of six-pointed stars or hexagonal tables, which are shaded in such a manner that similar stars appear within them, whose vertices project into the angles of the tables.

The salt is insoluble in water and in alcohol. When heated in a small tube, it decomposes suddenly and explosively, but does not detonate.

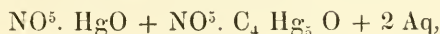
After drying over sulphuric acid, the composition of the salt was found to be as follows:

* Ann. Ch. Pharm. LXXX, 111.

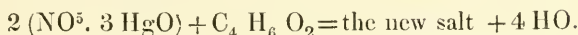
† See the preceding paper.

Calculation.			Experiment.		
C ₄	24	3.1	2.7	2.9	2.9
H ₂	2	0.3	0.4	0.3	0.3
Hg ₆	600	78.3	78.4		
N ₂	28	3.3	3.6		
O ₁₄	112	15.0			
	766	100.0			

These numbers agree with the formula,



which formula is conformed by the equation,



That this salt is a mercuric and not a mercurous salt, is shown by its property of dissolving completely in hydrochloric acid, without leaving a trace of calomel; it evolves, however, when thus treated, the peculiar odoriferous substance mentioned by Sobrero and Selmi. The solution in hydrochloric acid is precipitated yellow by potash.

When a strong solution of potash is poured upon the new salt, it turns grey; by boiling with the same solution, it turns black, without however being completely decomposed. The black substance is always mixed with crystals, however long the boiling may be continued. This black substance is not dissolved by hydrochloric acid, although but a small quantity of calomel is formed. It follows therefore that the salt is essentially altered by the action of potash.

Ammonia acts upon it in a similar manner.

A large quantity of mercurous nitrate is likewise found in the alcoholic solution from which the new salt has separated. A mercurous salt frequently separates in small needles after the new salt has been removed by decantation. The formation of mercurous salt probably depends upon secondary actions, for the mixture of alcohol and corrosive sublimate gives off a strong odour of aldehyde when heated, even though the action is not accompanied by any evolution of gas.

The new salt is acted upon by sulphuretted hydrogen, sulphide of mercury being formed, and likewise a body having the characteristic odour of mercaptan. Hence, in determining the mercury, the organic matter must be first destroyed by boiling the salt with aqua-regia, then evaporating to dryness, and digesting the residue in water. If this precaution be neglected, the mercury will come out 1 or 2 per cent too much, the sulphide collected on the filter being in fact impure.

The composition of the new salt leads to the supposition that the detonating oxide discovered by Sobrero and Selmi, is an oxide of

mercuric ethyl, that is, alcohol in which the hydrogen is replaced by mercury, $C_4 Hg_6 O_2$. Here then we have another instance of the striking analogy which exists between the products of the action of alcohol and of ammonia, that is to say, between the ethers and the amides. We know, indeed, that the ammoniacal oxide of mercury likewise detonates and forms characteristic salts.

On the Allotropy of Selenium.

By Dr. Hittorff.*

Our knowledge of the thermic relations of selenium is due to Berzelius, whose statements, as given in his treatise, have been copied without alteration into other compendiums of chemistry; they are as follows:

“Selenium becomes soft when heated, is semi-fluid at 100° , and fuses at a temperature a few degrees higher. During cooling, it remains soft for a long time, and may be drawn out like sealing-wax, into threads, which appear ruby-red by transmitted light. When solidified, it assumes a specular surface, exhibits perfect metallic lustre, and is altogether not unlike blood-stone. Its fracture is conchoidal and vitreous. When fused selenium is left to cool very slowly, its surface becomes uneven, granular, lead-grey, and no longer specular. The fracture is fine-grained, dull, and exactly resembles that of a lump of metallic cobalt. A second fusion followed by rapid cooling destroys this appearance, and restores to selenium its original external characters.”

A fact observed by the author of this memoir places the relation between crystalline and amorphous selenium in its true light, and shows that the preceding statements require correction. He finds, namely, that granular selenium does not fuse till heated to $217^\circ C.$, and that it then passes at once from the solid to the liquid state without previous softening. When cooled in the ordinary way, the fused mass does not return to the solid state at this temperature, but remains liquid, and passes through all degrees of softness, till, at a temperature below $50^\circ C.$, it gradually hardens into amorphous selenium. On plunging the bulb of a thermometer into fused selenium heated above $220^\circ C.$ in a small crucible, the temperature was found to fall quite regularly during cooling. There was no stoppage or retardation. The latent heat absorbed during the fusion of crystalline selenium is therefore not given up under these circumstances, but remains in the amorphous selenium, and is essential to that state. At lower temperatures, this condition of the selenium is stable.

* Pogg. Ann. LXXXI, 214.

Pieces of fused amorphous selenium, which the author has had in his possession for several years, have remained unaltered. The passage to the crystalline state, takes place, however, on exposing the amorphous selenium for a time to a temperature between 80° and 217° C., the latent heat being at the same time evolved.

In these experiments, an oil-bath was used consisting of three concentric copper cylinders. By means of a spirit-lamp of constant level and a stirrer, the oil of the inner vessel could easily be maintained for any length of time at a constant temperature. The amorphous selenium was placed at the lower part of a common test-tube, and fused round the bulb of a thermometer. The test-tube being introduced through an opening in the cover into the oil of the bath, in which a second thermometer is placed, the thermometer in the selenium soon takes the temperature of the medium, but instead of remaining at that temperature, quickly rises above it. By the time that it has returned to the temperature of the oil-bath, the amorphous selenium, on being taken out, is found to have assumed the granular condition. In amorphous selenium therefore, we have a substance, which, under these circumstances, softens when heated, then becomes semi-fluid, and afterwards returns to the solid state.

The conversion into the granular modification takes place most quickly, and the thermometer rises most above the temperature of the oil-bath when the latter is between 125° and 180° . With a quantity of selenium weighing about 20 grms., the thermometer usually rose from 40° to 50° above the temperature of the oil. The return to the latter temperature takes place very quickly.

A still greater rise of temperature is attained by using, instead of the oil-bath, an air-bath, which conducts away the heat less quickly. A convenient arrangement for the purpose is an ordinary drying apparatus, consisting of a copper cylinder having two apertures in its cover, so that a thermometer may be introduced through one of them, and the test-tube with the amorphous selenium and the second thermometer through the other. If now the cylinder be heated with a small spirit flame which raises the temperature to about 130° C., the naked thermometer rises at first, above that immersed in the selenium. But as soon as the latter has risen to 125° , it begins to mount rapidly, and soon attains a temperature between 210° and 215° .

The process of transformation is slower as the temperature of the bath is farther below 125° . The rise of temperature is then smaller, but continues longer. In the vapour of boiling water the process takes several hours, if the quantity be somewhat considerable; at 80° , it lasts much longer; in both these cases, the evolution of heat is imperceptible. The time required for the transformation depends greatly on the mobility of the particles. If the amorphous selenium

be not fused, but in the state of powder, it assumes the crystalline form so rapidly at 100° , and even at 90° , that the immersed thermometer rises from 25° to 30° . At 80° , in the vapour of ordinary spirit of wine, the rise of temperature is imperceptible even in this case. The greater the fluidity of the amorphous selenium, the more readily does it give up its latent heat. From this cause, the transformation takes place more slowly at temperatures above 180° , because the temperature of the selenium can never rise above 217° , the melting point of the crystalline variety. The latter can only be accurately observed by means of the oil-bath. For this purpose, the bath is kept at a constant temperature of more than 220° , and the crystalline selenium, together with the thermometer, immersed in it. The thermometer soon rises to 217° , then remains stationary for a long time between 217° and 218° , and finally attains the temperature of the oil. The selenium is then found to be melted.

On taking a general view of the thermic relations of selenium, it is impossible to overlook its strong resemblance to sulphur. It is well known, that the latter is obtained in a soft plastic state, by heating it above 250° , and then cooling it as quickly as possible, which is usually effected by pouring it into cold water. It then remains soft for a long time at the lower temperature, and returns but slowly to the crystalline state. This transformation, however, takes place quickly, as observed by Regnault,* if the sulphur be exposed to a temperature higher than the boiling-point of water. At the same time, an appreciable rise of temperature takes place; the thermometer immersed in the sulphur rises to 111° , the temperature of the medium being 98° .

The latent heat absorbed by sulphur heated to 250° , is unable to escape during the short time in which it cools; at a lower temperature it becomes more permanent, and requires several days to escape. It may possibly become quite stable at a still lower temperature at which the soft surface hardens. In the case of selenium, the latent heat takes a still longer time to escape, the time occupied in ordinary cooling, being in fact, insufficient for the purpose. At temperatures below 80° , the selenium hardens, retaining its latent heat, and the condition thus assumed is perfectly stable. Moreover, selenium not only retains that latent heat at ordinary temperatures, but under favourable circumstances, readily absorbs it. It is well known that selenium is obtained in the form of a red powder, when it separates from its compounds or solutions at ordinary temperatures. Thus, sulphurous acid, protochloride of tin, zinc, and iron, throw down red selenium from selenious acid; and seleniuretted hydrogen water deposits red selenium on exposure to the air. Both amorphous and crystalline selenium are dissolved by strong oil of vitriol at

* Pogg. Ann. LIII, 266.

40° C., and the green liquid when mixed with water, deposits red selenium. This red selenium, however, is nothing more than amorphous selenium in a state of minute division; for the latter also appears red in thin films by transmitted light, and gives a red streak. The red precipitate turns black when it is heated above 50°, softening at the same time, and agglomerating into a shining vitreous mass. Lastly, Count Schaffgotsch found the specific gravity of red selenium the same as that of fused amorphous selenium. Thus, the density of red selenium was found to be 4.259, and after aggregation 4.264, and that of the glassy modification 4.276—4.286, while that of granular selenium was 4.796—4.805 at 20° C. Precipitated selenium likewise gives out heat when it passes into the granular state. In the aggregated form it is the most convenient for this experiment; because it can then be easily pounded, and dried *in vacuo* over sulphuric acid. If it be then held in the vapour of boiling water, the thermometer rises, during the transformation, 125°—130°. Finely-divided red selenium gives off its water very slowly at ordinary temperatures; the author did not succeed in drying it completely. If exposed to the direct rays of the sun, it gradually becomes crystalline. To observe the escape of heat, it is best to apply a temperature of 80°, such as that afforded by the vapour of ordinary spirit of wine; at this temperature the transformation is very rapid.

Selenium is not always separated from its compounds in the amorphous state at ordinary temperatures. The solutions of selenide of potassium and selenide of ammonium, when exposed to the air, always deposit it in the crystalline form. The crusts which form on their surface are entirely made up of small crystals, which appear very distinct and definite under the microscope; their specific gravity at 15° C. is 4.808.

Vitreous and crystalline selenium differ greatly in their electrical conducting power. The former is known to be an insulator. Granular selenium conducts much better, and, which is very remarkable, its resistance is considerably diminished by heat. Two small plates of carbon were immersed in melted selenium contained in a crucible, and the amorphous mass brought into the crystalline state by exposing it to a temperature of 140° in the drying apparatus. It was then introduced, together with a galvanometer, having 200 turns of wire and an astatic needle, into the circuit of a single pair of Grove's battery. While the selenium was in the amorphous state, no deflection was produced upon the needle under these circumstances; but after the transformation into the crystalline modification, a deflection of 17° was produced at ordinary temperatures. On raising the temperature, the deflection increased still further, and at 210° C. it amounts to 80°. If this increase of conducting-power were to continue, the selenium when raised to a red heat, would conduct as well

as the ordinary metals; but after the absorption of the latent heat at 217° , the needle suddenly returns to 20° .

The allotropic states of sulphur and selenium are brought about by latent heat. The same cause probably produces similar effects in other bodies, although the relations are not so simple as those above considered.

The author is of opinion that Schrötter's red phosphorus is formed in a similar manner, viz., by the abstraction of latent heat from ordinary phosphorus, and that it is really the crystalline modification of the body, ordinary colourless phosphorus being the amorphous variety. It is true, that no crystalline structure has been detected in the red phosphorus; but on the other hand, it is always obtained either in a state of very minute division, or somewhat aggregated in crusts, conditions not very favourable to the observation of its structure.

On Phosphide of Tungsten.

By Wöhler.*

Phosphorus and tungsten combine directly, but without emission of light and heat, when finely-pounded metallic tungsten contained in a glass tube is heated to redness in phosphorus vapour. The resulting compound is a dull, dark grey powder, very difficult to oxidize, and composed according to the formula W^3P^2 . This formula requires 18.7 per cent of phosphorus; two experiments gave 18.38 and 18.87.

Much more remarkable is the phosphide of tungsten obtained by reducing a mixture of tungstic and phosphoric acids, at a very high temperature, in a crucible lined with charcoal. In this manner a compound is obtained, crystallized in magnificent geodes, having exactly the appearance of certain geodes filled with crystals, which occur in the mineral kingdom. The production of this beautiful arrangement was not the result of a single accident, but was repeated in four different experiments. In every case, there was formed a hollow mass of grey coke-like phosphide of tungsten, several inches high, more than an inch wide, corresponding to the dimensions of the crucible, and lined internally with the most brilliant crystals, many of which, though they were very thin prisms, attained a length of nearly an inch. They have a steel grey colour, and an exceedingly brilliant metallic lustre. They are six-sided prisms, apparently identical in form with gypsum. Their spec. grav. is 5.207. They

* Ann. Ch. Pharm. LXXIX, 244.

are perfect conductors of the electric current. When treated with zinc and dilute acid, they liberate hydrogen gas, and when immersed in a solution of a copper-salt they become covered with metallic copper.

This phosphide of tungsten undergoes no change when heated to the melting-point of manganese. It likewise remains nearly unaltered when heated to redness in the air. Heated on charcoal in a stream of oxygen gas, it burns with great splendour; and forms a deep blue sublimate on the charcoal. It likewise burns with an equally dazzling lustre on fused chlorate of potash. It is not attacked by any acid, not even by aqua-regia.

The proportion of phosphorus in this compound was found by three experiments to be 7.87, 8.70 and 8.78. The formula W^4P requires 8 per cent.

For the preparation of this very beautiful substance, crude phosphoric acid containing lime, and fused in an earthen crucible, was generally used; it was mixed in coarse powder with the tungstic acid, and generally in the proportion of 2 equivs. $PO^5 : 1 WO^3 = 9.7$. The quantity of tungstic acid used in each experiment was between 20 and 30 grms. The mixture was exposed in the charcoal crucible to a heat sufficient to keep nickel in a state of perfect fusion. In this manner, the largest and finest crystals were obtained, but the surrounding crust of phosphide of tungsten was intimately mixed with fused particles of slag, which could not be removed by any solvent. A less beautiful product was obtained by the use of pure phosphoric acid; but in this case also the remarkable formation of the hollow geode-space and the crystallization on its sides were exhibited. The formation of these crystals, which project freely and often perfectly isolated into the hollow, probably takes place in the liquid phosphoric acid, which at first remains undecomposed in the interior of the mass, and afterwards, being gradually reduced to the state of phosphorus, volatilizes, leaving the space hollow and intersected with the crystals previously formed.

On the Composition of Wolfram.

By J. Persoz.*

When crude tungstic acid, in the state in which it is obtained from wolfram, is fused with five or six times its weight of nitre, at a gradually increasing temperature, three distinct salts are obtained, possessing different characters, and derived from essentially different acids.

* Compt. Rend. XXXIV, 135.

If the heat be raised only a little above the melting-point of the nitre, part only of the crude tungstic acid is attacked ; and, on treating the product with hot water, we obtain a solution of a salt *A*, and an insoluble residue *x*.

The residue *x*, treated with a large excess of nitric acid at a temperature a little below that at which the nitre decomposes, becomes very fluid, but not transparent. On treating the product with boiling water, the excess of nitre is dissolved, together with a large quantity of another salt *B*, and there remains an insoluble salt *C*, which passes through the filter as soon as the wash-water becomes pure.

The solution *A*, when left to itself, first deposits free nitre, if any of that substance be present, and afterwards agglomerates into a mass of crystals, composed of nitre and water, together with a very small quantity of a salt belonging to the tungstic group. Boiling water decomposes these crystals, dissolving the nitre, and leaving a flocculent residue, which, when digested and frequently washed with hydrochloric acid, is converted into a *mealy powder*, very soluble in water, but insoluble in those acids which have a great attraction for water. The solution, when evaporated to dryness, leaves a yellowish-white residue, which, if unaccompanied by foreign matter, redissolves completely in water, forming a solution possessing strongly acid characters. This solution is not precipitated by nitrate of silver ; zinc reduces it, forming the blue oxide. When treated with acids which have a strong attraction for water, it loses its water of hydration, and reproduces the mealy powder above mentioned. When evaporated in vacuo, it leaves a yellow crystalline mass, which, if the acid is very pure, is composed of regular octohedrons.

Salt B.—This salt is composed of excess of nitre, mixed with tungstate of potash, properly so called.

Insoluble salt C.—When this salt is heated to redness with caustic potash, and the fused mass digested in water, a residue of oxide of iron is obtained, together with a solution, which, when treated with a slight excess of nitric acid, forms, on boiling, a milk-white, pulverulent precipitate, which is likewise an acid distinct from either of the preceding. This acid and all its salts exhibit the peculiar property of passing through the filter when washed with pure water. It resembles ordinary tungstic acid in most of its properties ; but differs from it by certain very decided characters ; for example, it changes from white to yellow when heated, and recovers its original colour on cooling. In other characters it seems to bear some resemblance to niobic acid.

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

VII.—*On a New Method of obtaining Hippuric Acid in considerable quantity without evaporation of the Urine; and on some of its Products of Decomposition.*

BY EDWARD RILEY, F.C.S.,

ASSISTANT AT THE MUSEUM OF PRACTICAL GEOLOGY.

The preparation of hippuric acid by the methods usually adopted is tedious, and involves considerable labour. Many processes have been proposed, but all experimenters on this subject have adopted the plan of evaporating the urine to $\frac{1}{6}$ or $\frac{1}{8}$ of its original bulk. H. Schwarz mentions,* in speaking of the preparation of hippuric acid, that a urine is rarely obtained which gives hippuric acid simply on the addition of hydrochloric acid, without evaporation. Löwig also mentions, that by the addition of hydrochloric acid to cow's urine, a crystalline precipitate is deposited, which the older chemists considered to be benzoic acid.

I shall now describe some experiments by which I have been led to a simplification of the method of preparing this acid. Three parts of fresh cow's urine obtained from the same cow were treated according to Liebig's process, as given in Turner's "Elements of Chemistry;" the cow from which it was voided was fed upon brewers' grains twice in the twenty-four hours, and allowed to graze on a neighbouring common. The urine was heated on a water-bath from a half to three-quarters of an hour with an excess of milk of lime, during which time distinct traces of ammonia were evolved; it was then filtered from the undissolved lime, neutralized

* Chem. Gaz. Aug. 1, 1845.

with hydrochloric acid, left slightly acid, and then evaporated to about $\frac{1}{8}$ or $\frac{1}{10}$ of its original bulk; the portion that crystallised on cooling was filtered from the residue, and purified by treating it three times with animal charcoal and lime, and then crystallising. Thus obtained, it was perfectly white, and in long acicular needles; but the quantity did not amount to more than from 5 to 10 grains.

The quantity being small, three other pints of urine were treated as above described, except that, after filtration the lime was left in excess; the evaporation was not so rapid as in the former case. From the small solubility of hippuric acid, I thought some might be obtained, although it was only evaporated to $\frac{1}{4}$ of its original bulk. Hydrochloric acid was added, an immediate precipitate was formed which appeared in exceedingly minute crystals, almost like an amorphous powder; this was filtered off. Thinking that more might possibly be procured, another portion of acid was added: a very considerable quantity, amounting to five or six times that previously obtained, was deposited, and removed by filtration. This unexpected result induced me to add another portion of acid, and as large a quantity was produced as in the second case; this was separated from the liquid, which now ceased to give any further precipitate on the addition of an acid. From these circumstances, it was obvious that hippuric acid must be more insoluble in a very acid solution in the cold, than in a solution slightly acidulated.

Hydrochloric acid was added to some of the urine that had not been used in the previous operation, and in a few seconds, crystals began to form, shooting out in needles from a nucleus; after it had stood a few minutes, the bottom of the flask was completely covered with a crystalline deposit of hippuric acid of considerable thickness. The amount of hippuric acid obtained from the three pints concentrated by evaporation, amounted to about 6 oz. by measure after the liquid had been decanted. These results led to some further experiments on the urine of cows. The urine from several cows was tested at various times, and generally gave large quantities of hippuric acid on addition of hydrochloric acid.

It was found from various experiments, that $\frac{1}{2}$ oz. of hydrochloric acid to a pint of urine, gave the best results. Sulphuric acid appeared to separate colouring matter.

Sometimes but little was to be obtained from the urine, at other times very considerable quantities were obtained. The urine was tested in the following manner: about 3 or 4 oz. of it were poured into a precipitating glass with about $\frac{1}{2}$ to $\frac{3}{4}$ of a drachm of hydrochloric acid. If no precipitate appeared it was vigorously

stirred, when hippuric acid would be precipitated in considerable quantity at the bottom of the glass. If, on the contrary, the liquid were not stirred, needle crystals would shoot out from a nucleus, some adhering to the sides of the glass, others falling to the bottom.

It was desirable to know the exact quantity of hippuric acid that could be procured: 1 pint of urine was taken from a cow, $\frac{1}{2}$ oz. by measure of commercial hydrochloric acid added; it was then allowed to stand twelve hours, filtered on two filters, one exactly counterpoising and encircling the other, and dried gradually in the air, until it ceased to lose weight. The weight thus obtained was

158·83 grains,

calculated per cent gives 2·269

„ per imp. gal. 1270·64 or 2·9 oz. avoirdupoise.

The hippuric acid was only slightly coloured. It was lightly scraped from the filter, and the filters were again weighed, when the excess was found to be 0·92.

This deducted, and calculated as before, gives 157·78 grains,

calculated per cent gives 2·252

„ per imp. gal. 1262·240 or 2·88 oz. avoirdupoise.

Thus showing, that the little colouring matter on the filter made no appreciable difference, in fact, some small quantity of hippuric acid was left adhering to it.

The method of obtaining and purifying the hippuric acid was as follows: the urine was caught from five to seven in the morning from seven cows, the urine from each being put into a separate vessel; each urine was tested in the manner before described; that which gave an immediate precipitate on stirring, was poured into a large vessel, whilst the rest was rejected. It was mixed with commercial hydrochloric acid in the proportion of $\frac{1}{2}$ oz. by measure to a pint; this was left until the evening, when the hippuric acid was decanted from the supernatant liquor, and was afterwards thrown on a square filter; the urine collected during the day, was then treated in a similar manner, and filtered off the following morning. I have in this way, obtained from a gallon, as much as would twice fill a small 2 oz. ladle when pressed down tight, and sometimes rather more; the hippuric acid was freed from the excess of urine, by twisting it in a piece of linen into a ball, and then squeezing it until no more liquid was expressed.

When about seven of these measures had been obtained, amounting

to $1\frac{1}{2}$ lb. by weight, of the moist hippuric acid, all the urine being expressed that was possible by simple pressure, it was placed in a large thin milk-pan, of a capacity of $2\frac{1}{2}$ gallons, rain-water added, and an excess of lime, and about 3 oz. of commercial animal charcoal; the milk-pan was then placed over an ordinary washing-copper, and the water in the latter heated to boiling. The mixture was heated until all the hippuric acid was dissolved, then kept at the same temperature about half an hour longer, filtered through large filters into another similar pan, replaced on the copper, heated until the temperature did not rise, then neutralized with hydrochloric acid, and about 4 to 5 oz. by measure more of the hydrochloric acid added. It was carefully covered and left until the next morning, when the liquid was found to be still luke-warm; but magnificent crystals, of the square prismatic form, sometimes 2 inches in length, were found adhering to the sides and bottom of the dish; the dish was allowed to cool on the copper, which was not cool on the evening following that on which it was purified. The crystals were drained, and allowed to dry between blotting-paper. The crystals thus obtained had only a slight tinge of colour, being sometimes rather more, sometimes rather less than $\frac{1}{2}$ lb. in weight. I have occasionally obtained them nearly white, by the first crystallization, when the animal charcoal was good. By repeating the above operation on the crystals, they may be obtained in beautiful snow-white prisms, without a tinge of colour. It often happens that the whole of the hippuric acid does not crystallize out, that sometimes considerable quantities may be obtained by adding 4 or 5 oz. of hydrochloric acid to the mother-liquor; a small portion of the mother-liquor should always be tested, to see whether any more acid may be obtained from it; this sometimes happens in purifying the acid at one time, whilst not at another.

The acid prepared in the above manner was submitted to analysis, after being twice recrystallized from distilled water, to purify it from a trace of lime which it invariably contains; when prepared as above, it gave, on analysis, results agreeing with the established formula: $C_{18}NH_8O_5 + HO$.

It is important to know from what food the greatest quantity of hippuric acid is produced. The observations made on this subject tend to show, that when cows are fed on grass, the hippuric acid exists in the urine in the largest quantity. The urine from cattle fed on other food does not give so large a quantity of hippuric acid.

I think we may infer (though perhaps not without a doubt), that the hippuric acid is obtained from the grasses in the pastures, some

of which contain a peculiar substance, cumarin, thought to be benzoic acid previously to the examination of Dr. Bleibtreu,* which probably may, by its passage through the animal organism, be transformed into hippuric acid, the cumarin occurring in the *Anthoranthum odoratum*, or spring grass, common in our meadows; also in the *Melilotus officinalis*, or melilot, and in the *Asperula odorata*, or woodruff. This subject I hope to investigate.

Through the kindness of Professor Miller, of Cambridge, I am enabled to give the form of the crystals of hippuric acid, which, previously to his examination, I thought I had succeeded in obtaining in two different forms; but he assures me they are similar.

Prismatic symbols of the simple forms:

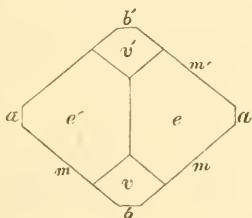
a 100, b 010, c 001, e 101, v 011, m 110, r 111.

The face c is common to the zones ee' , vv' ; c is common to the zones eb , va .

The faces a , b , c , r , are very small.

The angles between normals to the faces are:

	bc	90°	$0'$
	ca	90	0
	ab	90	0
	vv'	91	35
	ee'	81	32
	mm'	79	58
	em'	65	11
	ve	58	7
	vm'	56	42
	rv	31	1
	rm	36	41



Cleavage c , tolerably perfect.

Strong acids, as is well known, decompose the hippuric acid into benzoic acid and glyocol. Dilute nitric acid may be used to purify hippuric acid, the nitric acid only destroying the colouring matter. I have in this way obtained very good crystals, free from colour. Strong hydrochloric acid readily dissolves hippuric acid; and after boiling some time, the mass becomes turbid, and an oily substance of a dark colour floats on the surface, viz., benzoic acid, which crystallizes on cooling, and may be separated by filtration from the hydrochlorate of glyocol, which remains in solution.

The benzoic acid thus obtained, being submitted to sublimation in

* Mem. Chem. Soc. III, 205.

the apparatus described by Mohr, gives beautiful crystals of perfectly white benzoic acid, with only a slight odour.

I have obtained considerable quantities of benzoic acid by the above method, and am convinced that it might be prepared from this source much more economically than from gum benzoin.

I have also prepared glycol from the mother-liquor by the method of Dessaignes. In reference to this substance, I may mention that I have not been able to obtain the fiery-red colour mentioned by Mr. Horsford, on heating glycol with a strong solution of potash. Schwarz* makes the same observation.

I have prepared glycol by the action of sulphuric acid on hippuric acid, which appears to act as well as hydrochloric acid. The excess of sulphuric acid is removed, and the sulphate of glycol decomposed by precipitated carbonate and a little hydrate of baryta, whereby a sweet solution is obtained which crystallizes in apparently different crystals to those prepared by the action of hydrochloric acid on hippuric acid; they all effloresce on exposure to the air. They have not been analyzed.

VIII.—Contributions towards the history of Tannic Acid.

BY DR. STRECKER.

(FROM A LETTER TO DR. HOFMANN.)

The opinions of chemists regarding the transformation of tannic into gallic acid are still divided. Whilst some assume that tannic acid splits into gallic acid, carbonic acid and water, Mulder has lately asserted that the whole amount of carbon in tannic acid passes over into gallic acid, only water being assimilated, so that the two acids would contain the same number of carbon equivalents; and Wetherill has even gone so far as to consider tannic and gallic acids as isomeric.

The observation that the distillation of tannic acid, even when conducted with the utmost care, invariably yields a certain amount of a non-volatile residue, whilst, according to the old formula, it should split exactly into pyrogallie acid, carbonic acid and water, together with the well-known fact that the action of powerful acids upon tannic acid invariably gives rise to the formation of an ulmin-like body, whilst gallic acid is not affected by acids of the same

* Chem. Gaz. 1850, 475.

concentration, suggested to me the idea that tannic acid might contain another compound in addition to gallic acid.

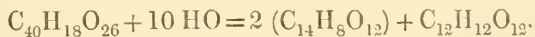
On examining the question, I have arrived at the curious result that tannic acid, when acted upon by acids, yields, together with gallic acid, *sugar*, so that henceforth tannic acid may be classed with the conjugate sugar-compounds. I have thrown down a solution of pure tannic acid with sulphuric acid; boiled the precipitate of sulphate of tannin with water, or very dilute sulphuric acid; neutralised the solution with carbonate of lead; and precipitated the gallic acid still dissolved with acetate of lead. The liquid, when freed from the excess of acetate of lead by hydrosulphuric acid, gave, on evaporation, a syrupy residue, possessing all the properties of sugar, modified by acids. It reduced an alkaline solution of protoxide of copper, although it did not contain a trace of gallic acid (which produces the same effect), and readily fermented on addition of yeast. This latter experiment appears to me conclusive. Accordingly, the formula of tannic acid will have to be altered; and although I have not yet been able to determine the quantity of sugar which is produced by a known weight of tannic acid, I nevertheless even now believe that the composition of this substance is represented by the formula :



as will be seen from the subjoined comparison of the numbers found and calculated :

	Theory.	Berzelius.	Liebig.	Mulder.	Strecker.
C_{40} . .	51·5	51·5	51·5	51·5—52·1	51·4—51·5
H_{18} . .	3·8	3·8	4·1	3·6— 3·9	3·9— 3·9
O_{26} . .	44·7	—	—	— —	— —
	100·0				

Thus the transformation would take place according to the following equation :



As the number of water-equivalents which is assimilated in this change is unusually large, the question arises whether tannic acid is a perfect analogue of the other conjugated sugar-compounds; at all events, we have to assume a hydrate of carbon in a state of conjugation.

From these experiments it is evident that this conjugate sugar-compound belongs to the principles most universally diffused in vegetable nature, and it can scarcely be doubted that the other tannin-like substances will have an analogous composition.

IX.—*On the detection and qualitative separation of Tin, Antimony, and Arsenic; and on the relation existing between these metals, and others which are precipitated from their acid solutions by Sulphuretted Hydrogen.*

BY CHARLES L. BLOXAM.

The difficulty which I experienced, some years since, in the analysis of the alloy known as Britannia Metal, from the want of a certain and ready method of separating tin, antimony, and arsenic, induced me to undertake a close investigation into the reactions of these three metals; and the results of this inquiry have appeared to me to possess so much interest, that I venture to lay them before the Society.

There is, perhaps, no problem in the whole range of qualitative analysis which has engaged so much attention, and so repeatedly defied all attempts at solution, as the separation of the three metals under consideration; and the reason of this is, evidently, the great similarity in properties exhibited by two of the metals, antimony and arsenic, conjoined with the disposition of the third, tin, to form an insoluble binocide, which enters into combinations, likewise insoluble, with the oxides of antimony and arsenic.

Before describing the method which I have found the most effective for the separation of these metals, I shall briefly pass in review some of those which have been already proposed for effecting this object. In doing this, however, I shall only mention those methods which are applicable in ordinary qualitative analysis, omitting those which were designed only for the separation of the metals in particular cases, as well as those processes which require a great expenditure, either of time or skill, on the part of the analyst.

The observation made some years ago by Levol,* that the three metals could not be separated by means of nitric acid, perfectly coincides with the result of my own experiments, which have shown that small quantities of arsenic are not dissolved out of a mixture containing tin, antimony, and arsenic, by nitric acid.

The method proposed by Simon† for the detection of small quantities of arsenic in the presence of antimony, consists in fusing the mixed sulphides of these metals with nitrate of potash, extracting the fused mass with water, acidulating the filtered solution with nitric

* Ann. Chim. Phys. [3] XVI, 493.

† Pogg. Ann. XL, 411.

acid, adding nitrate of silver, and precipitating the arseniate of silver by the careful addition of ammonia.

In order to ascertain whether this method could be applied to the separation of the three metals in cases where but a small quantity of arsenic is present, I prepared a solution containing

	0·0475	grm. antimony,
	0·0475	„ tin,
and	0·0050	„ arsenic,

(corresponding to 47·5 per cent of antimony, 47·5 per cent of tin, and 5 per cent of arsenic,) but failed in detecting the arsenic by treating the precipitated sulphides according to the method detailed above. I have found, moreover, as would be expected, that this method is very unsafe, even for the detection of larger quantities of arsenic; since it is very difficult to add exactly the amount of ammonia necessary to neutralize the free acid, and it is well known that the arseniate of silver is soluble in the slightest excess, either of nitric acid or of ammonia.

I have also tried to apply to the separation of antimony, tin, and arsenic, the method recommended by Meyer* for the separation of antimony and arsenic. This method consists in fusing the mixed metals (antimony and arsenic) or their sulphides, oxidised by nitric acid, with nitrate of soda, and extracting the arseniate of soda from the fused mass with water, which leaves the antimony in the residue. Since, if tin were present, it would also be left in the residue, I thought it might be practicable to separate the antimony and tin by treating this residue with tartaric acid. Bisulphide of tin was dried and fused with nitrate of soda; the fused mass was extracted with cold water; the aqueous solution was perfectly free from tin; the residue was washed, and boiled with a concentrated solution of tartaric acid, the solution filtered, mixed with hydrochloric acid, and subjected to a current of sulphuretted hydrogen, when a yellow precipitate of bisulphide of tin was obtained.

Moreover, when tersulphide of antimony was treated according to this process, the residue left by water could not be entirely dissolved by tartaric acid.

These experiments proved that no dependence could be placed upon this method for the separation of antimony and tin.

Some experiments have also been tried upon the method recently proposed by Fleitmann† for the detection of tin, antimony, and arsenic.

* Ann. Ch. Pharm. LXVI, 236.

† Ann. Ch. Pharm. Jan. 1851.

This method consists in testing for arsenic in one portion of the solution, by adding excess of potassa, and boiling with metallic zinc, when, if arsenic be present, arseniatted hydrogen will be evolved, and may be recognised by its property of blackening a solution of nitrate of silver; whilst antimony and tin are detected by treating the other portion of the solution with zinc and hydrochloric acid, and kindling the hydrogen which is evolved; the flame of antimoniated hydrogen is known by its depositing, upon a porcelain plate, a spot of antimony, insoluble in solution of hypochlorite of soda, whilst the arsenic spot is soluble in this reagent. The tin is then detected by boiling the metals reduced by zinc, with hydrochloric acid, and testing the solution for protochloride of tin with hydrosulphuric acid.

In order to prove this method, I employed it in testing a solution containing

	0.095	gram.	tin
and	0.005	„	antimony,

when the metallic stain, deposited upon a porcelain dish, was not redissolved by solution of chloride of soda (prepared by transmitting a very slow current of chlorine through a dilute solution of carbonate of soda, until it was but slightly alkaline).

On the other hand, when a solution containing

	0.095	gram.	tin
and	0.005	„	arsenic

was employed, the metallic stain was instantly dissolved by solution of chloride of soda.

I could not succeed in detecting the antimony by this method in solutions containing respectively :

	0.099	gram.	arsenic
and	0.001	„	antimony,
	0.495	gram.	arsenic
and	0.005	„	antimony,
			and
	0.095	gram.	arsenic
and	0.005	„	antimony,

since, in these three cases, the very large metallic crusts which were deposited upon the porcelain, dissolved entirely in solution of chloride of soda.

Hence it appears, that this method does not enable us to detect even 5 per cent of antimony in a mixture of that metal with arsenic.

The test for arsenic furnishes results which are far more satisfactory.

A solution containing

	0.095	grm. tin
and	0.005	„ arsenic

was mixed with a considerable excess of potash, and a few fragments of granulated zinc (free from arsenic) introduced; the flask containing the mixture was then fitted with a perforated cork carrying a short piece of wide glass tube, and heated to boiling upon a sand-bath; when a piece of paper spotted with solution of nitrate of silver was held over the extremity of the tube, the black arsenide of silver was immediately formed.

In another experiment, a solution containing

	0.495	grm. antimony
and	0.495	„ tin

was treated according to the above method; no black spot was visible upon the paper, but when 0.01 grm. arsenic was added to the mixture, a black spot was at once produced.

Other experiments were tried, all tending to show that this test is a most valuable one for arsenic in the presence of antimony, and will probably be found of great service in judicial investigations, especially as it may, in all probability, be applied equally well to a potash solution of the sulphides of these metals.

The objections which seem to me, therefore, to restrict the application of Fleitmann's method, have regard chiefly to the test for antimony, since it has been shown that small quantities of this metal may escape detection; moreover, the solution of chloride of soda cannot be preserved for any length of time, and the operation requires a special apparatus, which it is well, if possible, to avoid in qualitative analysis.

I have attempted to apply, qualitatively, the last method proposed by Rose* for the quantitative separation of tin, antimony, and arsenic, which consists in fusing the mixed oxides (obtained by treating the metals with nitric acid) with caustic soda, digesting the fused mass with water, and precipitating the last traces of antimoniate of soda by means of alcohol.

Tersulphide of antimony was oxidised with nitric acid, dried, and fused with a large excess of hydrate of soda in a silver crucible; the fused mass was digested with cold water, and set aside for twelve

* Berl. Monather. ; Pogg. Ann. LXXIII, 582.

hours; the solution was then filtered, and mixed with somewhat more than one-third of its volume of strong alcohol, and allowed to stand during the night; a considerable quantity of antimoniate of soda was deposited, and, on filtering this off, and testing the clear liquid with hydrochloric and hydrosulphuric acids, scarcely a trace of antimony was detected.

When tersulphide of arsenic was treated in exactly the same manner, and the aqueous solution of the fused mass was mixed with alcohol and allowed to stand for some hours, numerous small crystals were deposited, which, after washing with alcohol till free from adhering arsenic, were shown to contain this metal in considerable quantity; this circumstance, of course, would prevent the application of the method in qualitative analysis, since it appears that unless attention be paid to the strength and quantity of the spirit, as mentioned in Rose's paper, arsenic and antimony might both be found in the precipitate; moreover, I may cite, as an objection to the qualitative application of this process, the rather considerable quantity of substance required, which is seldom at our disposal in the examination of this group of oxides.

I have also found that a small quantity of arsenic cannot be detected in a mixture of the three metals, by this method of fusion with hydrate of soda.

An alloy containing a large quantity of tin, together with small quantities of antimony and arsenic, was oxidised with nitric acid, and the residue fused with excess of hydrate of soda; the fused mass was boiled with water, in which it almost entirely dissolved; the solution was acidulated with nitric acid, and filtered; the filtrate was carefully tested for arsenic by evaporating to a small bulk, mixing with excess of ammonia, evaporating to dryness, redissolving in water, and adding nitrate of silver, when no precipitate whatever was obtained; on the other hand, the precipitate produced by nitric acid in the aqueous solution of the fused mass, was mixed with charcoal, and reduced with cyanide of potassium and carbonate of soda in a crucible; the metallic button was found to contain arsenic.

Rose's method is also inapplicable in ordinary qualitative analysis to the separation of antimony and tin, because, previously to oxidation by nitric acid, these must be reduced to the metallic state, which cannot be conveniently effected when small quantities are to be examined.

The following experiment was made to ascertain whether the residue obtained by oxidising the tersulphide of antimony with nitric

acid would behave in the same way, when fused with hydrate of soda, as that produced by the oxidation of the metal.

Tersulphide of antimony was oxidised with nitric acid, dried and fused with a large excess of hydrate of soda; the fused mass was digested with cold water, and allowed to stand for twelve hours; the aqueous solution was filtered, acidulated with hydrochloric acid, and sulphuretted hydrogen passed; a considerable quantity of orange sulphide of antimony was precipitated.

When bisulphide of tin was oxidised with concentrated nitric acid, dried, fused for a considerable time with a large excess of hydrate of soda, and the fused mass digested for twenty-four hours with cold water, it slowly dissolved, leaving a very slight residue, which was filtered off, but passed through the filter when I attempted to wash it; a repetition of the experiment gave a similar result; this would point out a serious difficulty, since it would be highly important that the fused mass should form a perfectly clear solution, if no antimony were present.

An experiment has been tried upon the method of separation recommended in Galloway's manual of qualitative analysis.

Bisulphide of tin was gradually added to fused nitrate of ammonia, and the mixture heated for some time, until all nitrate of ammonia had volatilised, and finally, strongly ignited for some minutes. The ignited residue was boiled with a strong solution of tartaric acid, filtered, the solution mixed with hydrochloric acid, and sulphuretted hydrogen passed; a decided, though it must be confessed not very abundant, yellow precipitate was obtained. I had previously often observed the partial solubility of the binoxide of tin in tartaric acid, which may deceive us as to the presence of antimony.

The method of Levöl* for the separation of tin and antimony, which consists in boiling the finely-divided metals with hydrochloric acid, is inapplicable in ordinary analysis, because, unless the precautions pointed out by the author of this method be strictly adhered to, part of the antimony is dissolved by hydrochloric acid, as was originally shown by Elsner,† whose results have been confirmed by my own observations.

I have also tried some experiments upon the old method of separating tin and antimony by boiling the metals reduced by zinc, with nitric acid, and separating the mixed oxides thus obtained, by means of tartaric acid or bitartrate of potash.

Antimony which had been precipitated by zinc from a solution of

* Ann. Ch. Phys. XIII, 125.

† J. Pr. Chem. XXXV, 313.

the terchloride, was oxidised by heating with a mixture of concentrated nitric acid with two volumes of water; the oxide was well washed, and boiled with a saturated solution of tartaric acid for some hours; it would not entirely dissolve; the oxide prepared by using more dilute nitric acid dissolved to a somewhat greater extent. Bitartrate of potash was also tried with the same result.

Marsh's method of separating tin and arsenic, which consists in the evolution of the latter as arseniatted hydrogen by digesting the acid solution with zinc, is not applicable in ordinary analysis; firstly, because of the difficulty of obtaining, in every case, a solution free from nitric acid; secondly, because tin is sometimes an impurity of commercial zinc, and thirdly, because antimony interferes with the detection of the arsenic.

The process of Fresenius and Babo,* in which the arsenic is reduced by cyanide of potassium and carbonate of soda, in a stream of dry carbonic acid, is unexceptionable as far as the detection of arsenic is concerned; neither antimony nor tin interferes with this test; I have repeatedly tested pure sulphide of antimony by this method, without obtaining any trace of metallic sublimate. Unfortunately, however, so small is the quantity of the mixed sulphides that can be employed in this operation, that it is hopeless for an ordinary analyst to attempt the separation of antimony and tin in the residue.

After having satisfied myself that no certain and easy method existed of separating antimony, tin, and arsenic, I tried a great number of experiments with the view of discovering such a method; and since, in the course of these attempts, I have met with some reactions of these metals of which I nowhere find any account, I may perhaps be permitted to bring forward a few of them, as it appears to me a by no means unimportant branch of analytical science, to know what methods will not be competent to effect a particular separation.

Tersulphide of antimony was fused with Liebig's cyanide of potassium, with continual stirring; the mass was retained in fusion for some time; while fused, it had a deep brown colour, but became white on cooling; the mass dissolved entirely in water, and the solution gave an orange precipitate on addition of dilute hydrochloric acid; I was astonished, that in this experiment, no reduction of the antimony had taken place.

When bisulphide of tin was treated in a similar manner, globules of metal were obtained, and acetic acid, added to the aqueous solution, gave a yellow precipitate.

* Ann. Ch. Pharm. XLIX, 287.

When either bisulphide of tin or tersulphide of antimony was fused with nitrate of soda, and the mass extracted with cold water, neither metal was found in solution, but the residue left by water was, in each case, partly soluble in tartaric acid.

Tersulphide of antimony was added to fused chlorate of potash; the fused mass powdered, and boiled with water; much antimony was found in the aqueous solution; but when bisulphide of tin was thus treated, no tin whatever was found in the solution; when a mixture of bisulphide of tin with a little tersulphide of antimony was employed, all the antimony was left behind in the residue.

Tersulphide of antimony was fused with nitrate of potash, the mass powdered, and digested with cold water; the solution contained no antimony, and the residue was only partly soluble in hydrochloric acid.

Bisulphide of tin behaved in a similar manner.

When freshly precipitated tersulphide of antimony was oxidised with cold or hot concentrated nitric acid, a portion of antimony was found in the solution, and the residue was almost entirely dissolved when boiled with solution of tartaric acid. The nitric solution contained more antimony when a mixture of one volume of the concentrated acid with two volumes of water was employed. The tersulphide of antimony dissolved almost entirely, in a mixture of the concentrated nitric acid with four volumes of water.

On boiling bisulphide of tin with very dilute nitric acid, no tin was found in the solution.

A solution of terchloride of antimony was boiled with excess of carbonate of lime, and filtered; antimony was still found in considerable quantity in the solution.

When a solution of bichloride of tin was treated in the same manner, no tin was found in solution.

However, when a solution containing a large proportion of tin and a small quantity of antimony was neutralised with carbonate of lime and filtered, no antimony was found in solution; the same result was obtained on boiling.

In the course of my examination into the reactions of antimony and tin, I found that when a solution of terchloride of antimony was mixed with an excess of solution of sesquicarbonate of ammonia, and boiled, the precipitate at first produced was entirely redissolved; whilst, on making the same experiment with solution of bichloride of tin, no tin whatever was found in the filtered solution.

Thinking that this observation might lead me to the separation of these metals, I examined the reaction more minutely, and invariably

found that no tin could be detected in solution after boiling with an excess of sesquicarbonate of ammonia. I discovered, however, that occasionally this reagent produced, in a solution, of terchloride of antimony, a precipitate which was not perfectly soluble in excess, although a large quantity of antimony was invariably found in the solution. Finding that this precipitate was always less after boiling the terchloride of antimony with a little nitric acid, I tried whether the treatment of the solution with powerful oxidising agents would ensure the complete solubility of the precipitate. With this view, I tried successively, chlorine, chloride of soda, and chlorate of potash, in the presence of free hydrochloric and nitric acids, but always with the same result, namely, that although in many cases the precipitate was entirely soluble in excess, it depended so much upon the strength of the solution and upon the amount of sesquicarbonate of ammonia added, that it would be in vain to attempt or expect the complete solution of the antimony, although it was invariably found that the tin was entirely precipitated. I therefore determined to have recourse to a special method for the detection of tin in the precipitate. After several trials, I found that the best special reaction for this metal was that of the hydrochloric solution with protochloride of mercury, by which an incredibly small amount of tin may be detected. The precipitate produced by sesquicarbonate of ammonia was fused with cyanide of potassium, the fused mass digested with water, and the reduced metal boiled with hydrochloric acid; the filtered hydrochloric solution was then tested with protochloride of mercury, when, if a very small quantity of tin was present, it gave a very highly crystalline precipitate; with a larger quantity, a precipitate not visibly crystalline; and when very much tin was present, a grey precipitate of metallic mercury.

In order to ascertain to what extent the above method was applicable to the separation of antimony and tin in the ordinary course of analysis, I analysed solutions containing weighed quantities of these metals, always proceeding according to the following routine.

The solution containing the two metals was precipitated by sulphuretted hydrogen; the sulphides washed upon a filter, dissolved in yellow sulphide of ammonium, reprecipitated by hydrochloric acid, with addition of a little hydrosulphuric acid; the precipitate, after washing, dissolved in hydrochloric acid with a little nitric acid; the solution mixed with an excess of sesquicarbonate of ammonia, boiled for a few minutes, filtered; and the filtered solution, after concentration, tested for antimony, by acidulating with hydrochloric acid and passing sulphuretted hydrogen.

The filter, with the white precipitate produced by sesquicarbonate of ammonia, after washing twice or thrice with this reagent (for, when washed with water, it passes through the filter), was dried, incinerated in a porcelain crucible, the ash fused with a little cyanide of potassium, and treated as above described, in order to detect the tin.

By this process I have succeeded perfectly in detecting the two metals, even in cases where they have been mixed in the proportions of 99 to 1, and when only 0.003 grm., or even less, of the metal which was in small quantity, has been present. In these cases, the tin was always present in the form of bichloride, and the antimony either as trichloride or pentachloride.

I may mention, as an important precaution when testing for traces of tin, that the reduced metal should not be boiled for any considerable period with hydrochloric acid, since I have found that the reaction with protochloride of mercury cannot then be obtained; whereas, it is quite sufficient to raise the acid to the boiling-point, when the merest trace of tin may be detected.

In the course of these experiments, I have also found that the pure canary-yellow colour of the bisulphide of tin may be altered, in a very remarkable manner, by the presence even of very small quantities of antimony; in fact, most ordinary solutions of bichloride of tin were found to give a greenish-yellow precipitate from this cause, and a very slight admixture of antimony in a solution of tin could be detected in this manner.

A solution containing

	99.95 parts of tin, as bichloride,
and	00.05 „ antimony, as trichloride,

gave, with sulphuretted hydrogen, a precipitate which had a decided green tinge when compared with pure bisulphide of tin.

With a solution of

	99.45 tin
and	00.55 antimony,

the precipitate had a distinct green colour; and on increasing the proportion of antimony, it became very dark. I thought at first that the dark colour might be due to the presence of protochloride of tin, but could not detect any in the solution.

Having satisfied myself of the accuracy of the above process for the detection of the tin and antimony, I next inquired how far the presence of arsenic would interfere with it. I found that when

arsenic was present, the addition of sesquicarbonate of ammonia failed to throw down the whole of the tin; and in a case where the latter amounted to 5 per cent of the arsenic, no precipitate whatever was produced by sesquicarbonate of ammonia; moreover, the presence of arsenic of course interfered with the subsequent detection of the antimony in the filtrate from the binoxide of tin. It therefore became necessary to find some method of separating the arsenic from the antimony and tin, before taking any steps to separate these metals from each other.

Finding that, as I have already stated, all the tin was precipitated from a solution of the bichloride by carbonate of lime, even in presence of chloride of ammonium, and that arsenic acid appeared not to be precipitated at all under the same circumstances, I attempted to detect by this method, 1 part of arsenic, as arsenic acid, in the presence of 20 parts of tin in the form of bichloride, but found that the whole of the arsenic was carried down with the binoxide of tin.

I also tried to separate them by oxidising the sulphides with nitric acid, and fusing the residue with cyanide of potassium at a high temperature, but found that arsenic could not be entirely expelled in this way.

When a mixture of bisulphide of tin and tersulphide of arsenic (containing 1 part of tin to 20 parts of arsenic) was oxidised with nitric acid, the residue dried, ignited; and boiled with water until the aqueous solution gave no further indication of arsenic, this metal could still be detected in the residue.

It was found that when the residue obtained by oxidising a mixture of bisulphide of tin and tersulphide of arsenic (containing equal weights of these metals) with nitric acid, was fused with hydrate of soda; the fused mass dissolved in water; an excess of nitric acid added; the solution evaporated to dryness; and the residue boiled with water; the merest trace of arsenic was found in the solution.

This experiment was repeated with the same result.

A mixture of bisulphide of tin and tersulphide of arsenic containing equal weights of these metals, was fused with nitrate of potash; the fused mass dissolved almost entirely in water, and the aqueous solution, when acidulated with nitric acid, and heated, gave an abundant precipitate, which, after thorough washing, was found to contain arsenic.

Having failed in these attempts to discover a method for the complete separation of arsenic, I had recourse to the extraction of the sulphides of arsenic from a mixture of these with the sulphides of

tin and antimony, by means of sesquicarbonate of ammonia, a method which has been occasionally employed by other analysts.

I found that when pure tersulphide or pentasulphide of antimony was digested, either with or without heating, in a solution of sesquicarbonate of ammonia (prepared by agitating the commercial salt with cold water as long as any was dissolved), very small quantities of the sulphides were taken up, so small indeed, that this degree of solubility did not appear likely to interfere in analysis, whilst the two sulphides of arsenic dissolved at once in this reagent.

When bisulphide of tin was treated in the same manner, none was dissolved, even on boiling with sesquicarbonate of ammonia.

To ascertain how far the solubility of the sulphides of antimony would affect the result if sesquicarbonate of ammonia were used, I precipitated, by sulphuretted hydrogen, a solution containing bichloride of tin and terchloride of antimony, in the proportions of 99 parts of tin to 1 part of antimony, dissolved the precipitated sulphides in yellow sulphide of ammonium, reprecipitated by hydrochloric acid, and digested the precipitate with a saturated solution of sesquicarbonate of ammonia. I found that, although a little antimony was contained in the solution, the greater part remained in the residue, and the same result was obtained in several experiments.

The next question to be decided was, how far the behaviour of the sulphides of arsenic with sesquicarbonate of ammonia would be modified by the presence of those of antimony and tin.

Sulphuretted hydrogen was passed through a solution containing arsenic and antimony in the proportion of 99 : 1 (about 0.004 gram. of antimony being present), the arsenic as arsenious acid dissolved in hydrochloric acid, and the antimony as terchloride. The precipitate thus obtained was washed, and digested in a saturated solution of sesquicarbonate of ammonia, with the aid of a gentle heat; a fine orange-yellow residue of tersulphide of antimony was left undissolved. This experiment was repeated many times with the same result.

When the proportion between the two metals was reversed, there being about 0.0035 gram. of arsenic present, the latter was detected with great ease in the solution of the sulphides in sesquicarbonate of ammonia.

A solution containing

	0.0175 gram. tin, as bichloride,
and	0.0175 „ arsenic, as arsenious acid,

was precipitated by sulphuretted hydrogen, the precipitate washed,

dissolved in yellow sulphide of ammonium, reprecipitated by hydrochloric and hydrosulphuric acids, agitated with cold sesquicarbonate of ammonia and filtered; the filtrate contained a considerable quantity of bisulphide of tin. In some cases, where even a rather large amount of bisulphide of tin was mixed with the sulphide of arsenic, the precipitate dissolved almost entirely in sesquicarbonate of ammonia; and this is an additional instance of the strange alteration in the reactions of tin, to which the presence of arsenic gives rise.

In order to separate the tin from the arsenic, I ultimately resorted to a special method, which consisted in deflagrating the mixed sulphides (together, with the filter if necessary) with nitrate of potash, digesting the fused mass with water, when part of the tin was left behind in the insoluble residue, and acidulating the aqueous solution with nitric acid, which, on heating, precipitated the whole of the tin as binoxide. This precipitate, together with the residue left on digesting the fused mass with water, was washed, dried, and ignited with the filter; the ash fused with cyanide of potassium; the fused mass digested with water; and the residual metal boiled with hydrochloric acid; the filtered solution was then tested with protochloride of mercury for tin.

In a solution containing

	0.095 grm. arsenic
and	0.005 „ tin

the latter metal was very easily detected in this way.

The experiments detailed above led me to the following method for the qualitative detection of tin, antimony, and arsenic, which is applicable to any solution in which these metals exist, provided that any arsenic acid is first reduced to the state of arsenious acid.

The solution is largely diluted with water acidulated with hydrochloric acid, and sulphuretted hydrogen passed through it, to saturation; the liquid is allowed to stand for some time in a warm place, and the precipitate collected upon a filter; this precipitate is now washed several times with water, and dissolved, with the aid of heat, in yellow sulphide of ammonium; the solution thus obtained is mixed with an excess of hydrochloric acid, and some strong solution of hydrosulphuric acid; the reprecipitated sulphides, collected on a filter, well washed, transferred to a test-tube or small flask, and digested, at about 82° (180° F.), with a saturated solution of sesquicarbonate of ammonia, for about half an hour.

If the precipitate consisted of one of the sulphides of arsenic, it would entirely dissolve, but it must then be remembered that the

presence of tin is by no means precluded ; it may, however, be safely inferred that no antimony is present.

If there be any residue insoluble in sesquicarbonate of ammonia, it may contain bisulphide of tin and pentasulphide of antimony ; it must be washed, on the filter, with sesquicarbonate of ammonia as long as the washings furnish any considerable yellow precipitate when acidulated with hydrochloric acid ; it is then dissolved in a mixture of concentrated hydrochloric acid with about one-eighth of its bulk of concentrated nitric acid, using as little acid as possible. The solution is then mixed, in a beaker, with a considerable excess of sesquicarbonate of ammonia, and boiled for a few minutes. If no precipitate is produced, the absence of tin is certain, but if a precipitate is formed, it must be collected upon a filter for examination.

This precipitate may contain antimonie acid and binoxide of tin. It must be washed three or four times with sesquicarbonate of ammonia ; dried ; incinerated with the filter in a porcelain crucible ; a little cyanide of potassium added to the ash ; the mixture fused ; the fused mass boiled with water ; the reduced metal allowed to subside the supernatant liquid poured off ; the reduced metal (remaining in the crucible) heated to boiling with concentrated hydrochloric acid ; and the solution diluted with water, filtered, and tested for tin with protochloride of mercury.

The solution filtered from the precipitate produced by sesquicarbonate of ammonia in the nitro-hydrochloric solution of the sulphides of antimony and tin, will contain, under any circumstances, a part of the antimony ; in order to detect this metal, the solution is acidified with hydrochloric acid (when, if much antimony be present, a precipitate of antimonie acid will be at first produced, and afterwards redissolved by an excess of acid) ; a stream of sulphuretted hydrogen is then passed through the solution, when the production of an orange precipitate will at once indicate the presence of antimony.

We have now to examine the solution obtained by digesting the original sulphides with sesquicarbonate of ammonia. It has been already shown that this solution may contain both bisulphide of tin and pentasulphide of arsenic ; it is acidulated with hydrochloric acid, some hydrosulphuric acid added, and the precipitate divided into two equal parts, which are thrown upon separate filters, and washed, till the washings are free from chlorine.

One part of the precipitate is dissolved off the filter in warm ammonia, the solution evaporated to dryness on the water-bath, and

the residual pentasulphide of arsenic tested according to the method of Fresenius and Babo (reduced by cyanide of potassium and carbonate of soda, in a stream of carbonic acid).

The other portion of the precipitate, together with the filter, is dried, and deflagrated with nitrate of potash (the filter being cut into strips, and gradually added to the nitre in a state of fusion); the fused mass is poured from the porcelain crucible into one of iron, and when cool, boiled with water; nitric acid is then added till an acid reaction is produced; and the insoluble binoxide of tin collected upon a filter, dried, and tested for tin by the process described above for the examination of the former precipitate containing tin, which, in fact, might be advantageously examined together with this precipitate.

By this process, I have successfully examined solutions containing tin, antimony and arsenic in the following proportions, the tin being present as bichloride, the antimony as terchloride, and the arsenic as arsenious acid dissolved in hydrochloric acid.

	Arsenic.	Antimony.	Tin.
1	95.0	2.5	2.5
2	2.5	2.5	95.0
3	5.0	5.0	90.0
4	47.5	5.0	47.5
5	47.5	47.5	5.0
6	5.0	47.5	47.5
7	90.0	5.0	5.0

In these cases, the unit, of which the above numbers are multiples, was 0.001 grm.

These and similar analyses have been often repeated, not only by myself, but by individuals who had no previous acquaintance with this method, and even by beginners in the study of analysis, and the result has shown me that, with comparatively little care, more certain analyses can be made by this method than by any other which has come under my notice.

The process seems rather a long one for the object in view; I have made several attempts to shorten it by detecting the arsenic and

tin in one operation, but the result, when small quantities of the metals were present, was not satisfactory.

After having framed a method upon which I felt that I could rely for the separation of these three metals, I determined to ascertain how far these could be separated from the other metals of this group, the members of which form sulphides insoluble in dilute acids.

The only method, I believe, employed in general analysis to effect this object, consists in heating the mixed sulphides with sulphide of ammonium containing an excess of sulphur, which is known to dissolve the sulphides of tin, antimony and arsenic, together with traces of sulphide of copper, and small quantities of bisulphide of platinum and tersulphide of gold. It was necessary, in order to ascertain the efficiency of this method, to analyse various mixtures containing known weights of the metals to be separated, and I accordingly conducted a series of experiments of this nature, some of which I may perhaps cite.

In these experiments the method of proceeding was as follows :

The solution was acidified with hydrochloric acid, completely precipitated with sulphuretted hydrogen, the precipitate collected on a filter, well washed, and boiled for two or three minutes with the yellow sulphide of ammonium (prepared by the action of the air upon the hydrosulphate of sulphide of ammonium obtained by saturating solution of ammonia with sulphuretted hydrogen). The sulphide of ammonium solution was filtered off, and acidulated with hydrochloric acid, a quantity of a strong solution of hydrosulphuric acid was then added, and if the precipitated sulphur was in the slightest degree tinged, it was examined for antimony, tin, or arsenic, by the method given above.

On analysing a solution containing

	0.500	gram.	of lead
and	0.005	„	of tin,

a part of the tin was found in the sulphide of ammonium solution, showing that the bisulphide of tin was not retained to any considerable extent by the sulphide of lead.

The tin was also found in the sulphide of ammonium solution, when there were present

	0.500	gram.	bismuth
with	0.005	„	tin.

Also in the analysis of a solution containing

	0.100	gram.	gold
and	0.005	„	tin.

The tin was likewise distinctly detected in a solution containing

	0.500	gram.	platinum
and	0.005	„	tin.

When a solution containing

	0.500	gram.	mercury
and	0.005	„	tin

was analysed in this way, no tin was found in the sulphide of ammonium solution in two experiments.

When the same quantity of tin was present (0.005 gram.) together with only 0.250 gram. mercury, the tin was only just recognised in the sulphide of ammonium solution in two experiments.

In the examination of a solution containing

	0.500	gram.	cadmium
and	0.005	„	tin

no tin was found in the sulphide of ammonium solution (in two experiments), but when half the quantity (0.250 gram.) of cadmium was present, the tin was just recognised distinctly, in two experiments.

In the case of a solution containing

	0.01	gram.	tin
and	0.09	„	copper

no tin was found in the sulphide of ammonium solution, but abundance in the residue.

Even in the presence of only 0.03 gram. copper, the whole of the tin was found in the residue.

When equal weights (0.01 gram.) of tin and copper were present, most of the tin was found in the residue, although some was detected in the sulphide of ammonium solution.

Very little tin was found in the solution in sulphide of ammonium when

	0.03	gram.	tin
and	0.06	„	copper

were employed.

When

	0.030	gram.	tin
and	0.075	„	copper

were present (being in the proportion of 1 tin : 2.5 copper), very little tin was found in the sulphide of ammonium solution.

In the case of

	0·03 grm. tin
and	0·09 „ copper

a slight trace of tin was found dissolved in the sulphide of ammonium.

A scarcely perceptible trace was found in solution when

	0·03 grm. tin
and	0·12 „ copper

were employed, and when the copper was increased to 0·135 grm. (being in the proportion of 1 tin : 4·5 copper), no tin was found in the sulphide of ammonium solution.

Many of the above experiments were repeated several times, with different specimens of sulphide of ammonium.

I also made several attempts to analyse a specimen of gun-metal (containing 90 copper and 10 tin) by dissolving in aqua regia, precipitating the diluted solution with sulphuretted hydrogen, and boiling the precipitated sulphides with sulphide of ammonium, but could not succeed in detecting the tin in the sulphide of ammonium solution, though it was easily found in the residue.

It appears, then, from these experiments, that the extraction of bisulphide of tin from a mixture of this sulphide with those of lead, bismuth, gold, platinum, mercury and cadmium, is sufficiently complete for most practical purposes; but that, in the case of the two latter sulphides, if no tin be found in the sulphide of ammonium solution, we can only conclude that the proportion of the tin to either the mercury or cadmium, is not *greater* than that of 2 to 100.

In presence of copper, however, it appears that no safe conclusion as to the absence of tin can be drawn from the circumstance that this metal is not found in the sulphide of ammonium solution of the sulphides.

In the analysis of a solution containing

	0·005 grm. arsenic
and	0·500 „ lead,

the arsenic was detected in the sulphide of ammonium solution.

In a case where

	0·005 grm. arsenic
and	0·500 „ cadmium

were present, arsenic was found in the sulphide of ammonium solution.

When	0·005 grm. arsenic
was present with	0·500 „ mercury,

a considerable proportion of the arsenic was found in the sulphide of ammonium solution.

In analysing a solution containing

	0·500 grm. bismuth
and	0·005 „ arsenic,

less arsenic than I expected was found in the sulphide of ammonium solution, in two experiments.

In the case of

	0·150 grm. gold
and	0·003 „ arsenic,

the latter was distinctly found in the sulphide of ammonium solution, though in smaller quantity than was expected.

The same was observed with

	0·500 grm. platinum
and	0·005 „ arsenic.

No arsenic was found in the sulphide of ammonium solution in the analysis of mixtures containing respectively :

	1·00 grm. copper
with	0·01 „ arsenic
and	

	0·90 grm. copper
with	0·01 „ arsenic.

When	0·50 grm. copper
was present with	0·01 „ arsenic,

the latter metal was detected in the sulphide of ammonium solution, and was always found when smaller proportions of copper were present.

From these experiments, I inferred that the detection of arsenic is not influenced to any considerable extent by the presence of any metal of this group except copper, but that it is slightly affected by the presence of platinum, gold, bismuth, and lead.

If copper be present, the absence of arsenic, in any greater proportion than that of 2 to 100 copper, may be inferred if no arsenic is found in the sulphide of ammonium solution.

In the analysis of a solution containing

0.01 grm. antimony
and 1.00 „ copper,

the antimony was distinctly found in the sulphide of ammonium solution; and none was found in the residue left by sulphide of ammonium

when 0.01 grm. antimony
was present with 0.10 „ copper.

Antimony was also distinctly found in the sulphide of ammonium solution in the following cases :

0.005 grm. antimony to	0.5 grm. lead
0.005 „ „	0.5 „ bismuth
0.005 „ „	0.5 „ cadmium
0.005 „ „	0.5 „ mercury
0.005 „ „	0.5 „ platinum
0.005 „ „	0.1 „ gold.

The detection of antimony, therefore, does not appear to be influenced to any considerable extent by the presence of any other metal of this group.

Since the presence of copper may, to a considerable extent, prevent the detection of tin and arsenic by the ordinary method, it becomes necessary, when copper is present, to examine for those metals in that portion of the precipitate by sulphuretted hydrogen, which is insoluble in sulphide of ammonium.

For the detection of arsenic in this portion of the precipitate, I have usually resorted to the delicate test of Fresenius and Babo.*

The detection of tin, however, is more difficult; and the following method has yielded me the most certain results.

The residue left by sulphide of ammonium is collected on a filter, well washed, and boiled, as usual in the analysis of this precipitate, with a mixture of concentrated nitric acid with two volumes of water, to dissolve those sulphides which are soluble in this reagent; the residue, which contains the binoxide of tin, is collected on a filter, and washed; the filter, together with the precipitate, incinerated; the ash fused with cyanide of potassium; and the fused mass boiled with water. The residuary metal is heated with hydrochloric acid, and the solution tested with protochloride of mercury.

By this method the tin was easily discovered in the following cases :

* Ann. Ch. und Pharm. XLIX, 287.

1. 0·01 grm. tin, 0·24 grm. mercury, 0·24 grm. lead, 0·24 grm. copper, and 0·01 grm. cadmium.
2. 0·01 „ tin, 0·25 grm. mercury, 0·25 grm. lead, and 0·50 grm. copper.
3. 0·01 „ tin and 0·09 grm. copper.
4. 0·01 „ tin and 0·05 „ copper.
5. 0·01 „ tin and 0·03 „ copper.

In order perfectly to convince myself of the accuracy of this method for the detection of antimony, tin and arsenic, in the presence of considerable quantities of the other members of this group, I have made numerous analyses of solutions in which different proportions of these metals were present, and have not as yet met with a case where they escaped detection.

Two cases especially have engaged my attention, viz. :

	0·01 grm. antimony
	0·50 „ copper
with	0·10 „ tin,
	and
	0·24 grm. lead
	0·24 „ copper
	0·24 „ mercury
	0·01 „ bismuth
	0·01 „ cadmium
	0·01 „ antimony
	0·24 „ arsenic,

and in the latter I have satisfied myself that no mistake can arise as to the presence of tin from the reactions of the other metals of this group.

I have, moreover, employed this method in analysing various alloys for technical purposes, and have never been able to detect any false affirmation or negation of the presence of antimony, tin, or arsenic.

Incidentally to this investigation, I often observed that considerable quantities of cadmium escaped detection; on examining into the cause of this disappearance of the cadmium, I found, that when tin was present, a large proportion of cadmium might be left undissolved, when the sulphides insoluble in sulphide of ammonium were treated with dilute nitric acid (a mixture of 1 volume of ordinary concentrated nitric acid and 2 volumes of water).

In the solution containing

	0.24	grm. mercury
	0.24	„ lead
	0.24	„ copper
and	0.01	„ cadmium

the cadmium was very easily found in the solution of the sulphides in dilute nitric acid.

When 0.01 grm. tin, however, was added to the above solution, the cadmium could not be detected in the nitric solution.

I found that the cadmium was always detected, when the residue left by nitric acid was incinerated and fused with cyanide of potassium, in the process for the detection of tin. During the fusion with cyanide of potassium, a red-brown sublimate of oxide of cadmium was formed on the lid of the crucible; this sublimate was dissolved in hydrochloric acid, and the solution mixed with strong solution of hydrosulphuric acid, when a fine yellow precipitate of sulphide of cadmium was obtained. I mention this circumstance with regard to the cadmium, because it seems to me probable, that the (at present) unaccountable disappearance of some of the other members of this group of sulphides may hereafter be traced to some similar cause, and that analysts will be induced rather to rely upon special tests in a particular search after individual metals, regarding the general course of analysis, merely as affording a systematic method of ascertaining what substances enter largely into the composition of the matter under examination.

I hope to be enabled, at some future time, to continue this investigation, in order, either to assure myself of the efficiency of the method which is at present generally followed in the analysis of the precipitate produced in acid solutions by sulphuretted hydrogen, or to point out where the difficulties are to be expected, and how they may be overcome.

These experiments were conducted in the laboratories of the Royal College of Chemistry; and it gives me great pleasure to express my sincere thanks to Professor Hofmann, for the kind advice and assistance which I have received from him during their progress.

I subjoin, in a tabular form, the method which I now adopt for the detection of tin, antimony and arsenic, in the precipitate produced by sulphuretted hydrogen in a solution previously acidulated with hydrochloric acid.

The precipitate is well washed, and boiled for some minutes with yellow sulphide of ammonium.

The residue is washed till the washings contain no chloride of ammonium, and boiled with dilute nitric acid (1 vol. concent. acid and 2 vols. water).

The residue is collected on a filter, dried, and incinerated; the ash fused with cyanide of potassium; the fused mass boiled with water; the reduced metal heated to boiling with concentrated hydrochloric acid; and the solution diluted with water, filtered, and tested with protochloride of mercury. A white or grey precipitate (according to the quantity of tin) indicates the presence of tin.

The solution is examined as usual.

The solution is acidulated with hydrochloric acid, and mixed with some strong hydrosulphuric acid. The precipitated sulphides are washed, and digested at a gentle heat, with a saturated solution of sesquicarbonate of ammonia, for about half an hour, and filtered.

The residue is washed with solution of sesquicarbonate of ammonia, till the washings give no considerable yellow precipitate with hydrochloric acid, and dissolved off the filter in hot hydrochloric acid with a little nitric acid. The solution is mixed with excess of sesquicarbonate of ammonia and boiled for two or three minutes.

The precipitate is washed with a little sesquicarbonate of ammonia, dried, and incinerated, the ash fused with cyanide of potassium; the fused mass boiled with water; the reduced metal allowed to subside; the aqueous solution decanted; the metal heated to boiling with concentrated hydrochloric acid; the solution diluted with water, and tested with protochloride of mercury. White or grey precipitate; presence of tin.

The solution is slightly acidulated with hydrochloric acid, and sulphuretted hydrogen passed through it. If the precipitate has a pure orange colour, the presence of antimony may be inferred; but, in any other case, the precipitate should be collected on a filter; washed; boiled with concentrated ammonia; a few bubbles of sulphuretted hydrogen passed; and the solution filtered. The filtrate is acidulated with hydrochloric acid, and sulphuretted hydrogen passed. Orange precipitate indicates antimony.

The solution is acidulated with dilute hydrochloric acid, a little hydrosulphuric acid added, and the resulting precipitate washed and divided into two parts.

One part is dried and deflagrated (with the filter, if necessary), with nitrate of potash, the fused mass boiled with water; and the aqueous solution acidulated with dilute nitric acid. A white precipitate will indicate the presence of tin, which may be confirmed by drying this precipitate upon a filter; incinerating the latter; fusing the ashes with cyanide of potassium; washing the reduced metal; and boiling with hydrochloric acid. The hydrochloric solution may then be tested with protochloride of mercury.

The remainder of the precipitate is dissolved off the filter in warm ammonia; the solution evaporated to dryness on a water-bath; and the residue tested for arsenic according to the method of Fresenius and Babo.

X.—*Researches on the Constitution of Organic Acids.*

BY M. CHARLES GERHARDT.

COMMUNICATED BY DR. WILLIAMSON.

The experiments which I am about to lay before the Society, are intended as the commencement of a series of researches undertaken with a view to find a general expression for the molecular constitution of organic acids ; or rather, to explain the properties of double decomposition belonging to this class of compounds. I endeavoured to connect organic acids, numerous and various as they are, by a general formula which would be for them what the formula of ammonia is for the organic alkalies ; in a word, I sought among the compounds of mineral chemistry for a body which is reproduced by simple substitutions of one or other of its elements, as ammonia is reproduced from the organic alkalies by substitution of the groups methyl, ethyl, phenyl, &c., by one, two or three atoms of hydrogen. This term of comparison, this body, typical of acids, I believe I have found. For the understanding of my experiments, it is necessary to name this body at once. It is *water*, in the molecule of which I assume one atom of oxygen and *two* atoms of hydrogen,



two atoms which may be replaced by simple metals, or by complex groups like methyl, ethyl, &c.

The results obtained a short time ago on this subject by Dr. Williamson in England, and by M. Chancel in France, are well known. These chemists have indeed proved that alcohol, common ether, and their homologues, represent molecules of water in which the two atoms of hydrogen are partly or wholly replaced by complex groups ; so that common alcohol represents water in which half the hydrogen is replaced by the group ethyl ($\text{C}_2 \text{H}_5 = \text{Et}$)



whilst common ether represents the same molecule of water in which the two atoms of hydrogen are so replaced :



According to this theory, now almost universally adopted, the

compound formed by replacing one atom of hydrogen in alcohol by potassium, is to be considered as water in which the two atoms of hydrogen are replaced, one by ethyl, the other by potassium :



It may be called potassic ethylate, that is, the potassium-salt of an acid which is nothing else than common alcohol, a weak acid evidently, for water decomposes its salt into alcohol and caustic potash. In like manner, common ether is the ethyl-salt of this ethylic acid. The starting point for my experiments was supplied by this analogy, together with the fact that ethylic acid gives rise to a chloride (hydrochloric ether, or chloride of ethyl) when acted upon by pentachloride of phosphorus; and that, according to M. Cahours' experiments, various organic acids, such as benzoic, nitrobenzoic, cuminic, anisic, and cinnamic, experience an exactly similar change by the influence of the same reagent.

As potassic ethylate, in reacting on ethylic chloride, forms potassic chloride and ethylic ethylate, that is common ether (the experiment is well known), I sought with the chloride of one of the above-mentioned acids, and the potassium- or sodium-salt of the same acid to obtain a body corresponding to common ether; in other words, I sought to obtain the anhydrous acid, as ether itself is nothing but alcohol minus water.

With sodic benzoate and benzoic chloride, the experiment succeeds perfectly well. The soda-salt should be dried and mixed with an equivalent weight of the chloride; the mixture is then heated to 130° C. in a sand-bath, at which temperature a limpid solution is formed, which decomposes with deposition of chloride of sodium when heated a few degrees higher. The action is then complete, not a trace of gas is evolved, and the fearful smell of the benzoic chloride entirely disappears. The product suspended in cold water, and washed with carbonate of soda, leaves a white substance without odour, and perfectly colourless, which analysis shows to be anhydrous benzoic acid :



that is to say, benzoic benzoate; for it is to benzoic acid what ether is to alcohol, and if benzoic acid is represented similarly to alcohol, as water in which one atom of hydrogen is replaced by the group benzoyl $\text{C}_7 \text{H}_5 \text{O} = \text{Bz}$:



then my new substance is water, in which the two atoms are similarly replaced :



The following are the properties of this anhydrous benzoic acid. It is obtained in the form of beautiful oblique prisms, which melt at $33^{\circ}\text{C}.$; they are volatile without decomposition, insoluble in water, soluble in alcohol and ether; these solutions are perfectly neutral. When dissolved in hot alcohol, the acid is deposited, on cooling, in the form of an oil, which remains a long time without solidifying; the same thing occurs when the substance is distilled; in which case it sometimes remains liquid for several hours. Cold water has no action upon it; but boiling water transforms it, little by little, into common benzoic acid. The same transformation is effected in a few moments by boiling ammonia. Alcohol itself transforms anhydrous benzoic acid in the course of time into benzoic ether; the group benzoyl is then replaced by the group ethyl.

Having succeeded so well with the chloride of benzoyl and benzoate of soda, I made similar experiments with other chloride and other salts. I did not of course limit myself to cases of the action of chlorides upon salts of the same acid; but took the chloride of benzoyl, and successively, salicylate, cuminate, cinnamate and acetate of potash. Benzoic salicylate, cuminate and cinnamate were thus formed. These products are for the most part very fusible solid bodies, or oils heavier than water, without smell, and are rapidly decomposed by the alkalies in a similar manner to benzoic acid with alkalies. Several of them are not volatile without decomposition; thus the benzoic salicylate, when distilled in a moist state, decomposes into salicylic acid and a neutral body, fusible at $72^{\circ}\text{C}.$, which is the true benzoyl,* isomeric with the benzoyl of M. Laurent :

* There can be no doubt that this substance is identical with the compound discovered by Ettling among the products of distillation of benzoate of copper, which was subsequently analysed by Dr. Stenhouse, who gives the same formula, namely,

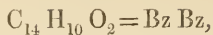


Stenhouse states that the fusing-point of this substance is 70° , and that it yields benzoate of potassa when heated with solid hydrate of potassa, hydrogen being evolved.

The compound



obtained by Ettling among the products of distillation of salicylite of copper, and described by him by the name of *parasalicyl*, has the same composition as M. Gerhardt's benzoic benzoyl, but differs from it in its properties, fusing as it does at 127° , and being, as it appears, only slightly acted upon by potassa. Probably this substance stands to benzoic benzoyl in the same relation as salicylic acid to benzoic acid.—A. W. H.



that is to say, it is to hydrogen, H_2 , what hydrated benzoic acid and anhydrous benzoic acid are to water. Hydrate of potash in a state of fusion converts it into benzoate, with evolution of hydrogen.

I will limit myself for the moment to this summary announcement of my experiments, and propose following them out with all the care which the subject requires.

If a general conclusion may now be drawn from these results, I would say that they destroy the kind of privilege hitherto enjoyed by a small number of bodies known by the generic name of alcohols, of being susceptible of joining other organic bodies. Alcohols and hydrated acids are evidently bodies of the same kind. Philosophically, alcohols, acids, ethers, salts, and anhydrous acids, may be reduced to the same generic formula—to the formula of water, in which 1 or 2 atoms of hydrogen are replaced, either by simple metals or by hydrocarburetted groups (methyl, ethyl, phenyl, &c.), or else by oxygenated groups (benzoyl, cuminyl, acetyl, &c.)

I have now succeeded in preparing anhydrous acetic acid in a state of perfect purity, and giving by analysis numbers exactly agreeing with those calculated from its formula. The following is the method of preparing it: Acetate of potash is fused, so as to expel all water of crystallization, and is then mixed in a small retort with about half its weight of benzoic chloride. On the application of a gentle heat, the reaction speedily occurs—benzoic acetate being no doubt formed at first. But the reaction does not stop there. A limpid body distils over, with a very powerful smell, reminding of acetic acid and flowers of "acebessine." On rectification, this liquid boils constantly at 137° C.; it falls to the bottom in water, and does not mix with it at once, but only after continued agitation. Hot water dissolves it at once, with production of acetic acid. The following figures show the result of combustion:

	Analysis.	Calculation.
Carbon . .	46.87	47.05
Hydrogen . .	5.95	5.88

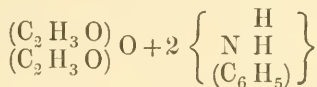
It is therefore $C_4H_6O_3$ or, rather $\frac{C_2H_3O}{C_2H_3O} \cdot O^*$

This anhydrous acetic acid evolves great heat on mixture with dry

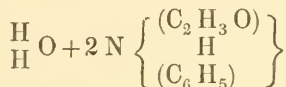
* A similar view regarding the constitution of acetic acid has been proposed by Professor Williamson.—Ch. Soc. Qu. J.—Eds.

aniline; the mixture solidifies entirely on cooling. If an excess of aniline is avoided, only one body is produced, crystallizing in beautiful nacreous plates. This body is shown by analysis to be acetaniline.

It is remarkable that no salt of aniline is formed at the same time. We must therefore consider the action as consisting of a double decomposition between the aniline and the anhydrous acid; thus



forms



We must, I think, consider amides and anilides as ammonia in which more or less hydrogen is replaced. I am now engaged in the investigation of this point.

Amidogen-acids would correspond to hydrated oxide of ammonium.

XI.—*Note on the Preparation of Carbonate of Amyl.*

By JOHN A. BRUCE,

OF THE ROYAL COLLEGE OF CHEMISTRY, LONDON.

Carbonate of amyl has been lately examined by Mr. Medlock, whose experiments have been described to the Chemical Society.* He obtained this compound by a method which had not yet been used for the preparation of carbonic ethers, namely, by the action of phosgene gas upon fusel-oil, and subsequent decomposition of the chlorocarbonate formed, under the influence of heat, in the presence of water. The process which originally had furnished the carbonate of the ethyl-series, and which consists in distilling the oxalate with potassium, has never been applied to the amyl-series.

The reaction of potassium upon the ether-oxalates being still but

* Chem. Soc. Qu. J. I, 368.

imperfectly understood, Dr. Hofmann requested me to repeat the experiment with oxalate of amyl, in order to obtain some additional data for a more correct interpretation of the phenomena attending the decomposition.

Potassium, when coming in contact with perfectly dry oxalate of amyl, is rapidly attacked, the liquid becomes warm, and a brown mass forms around the metallic globules, whilst a colourless inflammable gas is disengaged. The reaction, however, soon slackens, and only commences again on heating the liquid. On distilling the fluid, a brown residue was obtained, consisting chiefly of carbonate of potash and charcoal, while a pale-yellow distillate passed over; this liquid, when rectified with a thermometer, was found to consist of not less than four different substances. It began to boil at 130° C. (266° F.), at which temperature chiefly fusel-alcohol distilled; the boiling-point then rapidly rose to about 225° C. ($433\cdot4$ F.), when it became stationary for a very considerable time, indeed until three-fourths of the whole had passed over. The liquid distilling at this temperature was pure carbonate of amyl, as proved by the analyses hereafter to be detailed. The mercury then again rose until the temperature was 260° C. (500° F.), when it became once more stationary, but only for a short period, evidently because a small portion of undecomposed oxalate of amyl, which boils at this temperature, was still present in the liquid. After this had been evaporated, a viscous, somewhat dark residue, having a very powerful odour, remained in the retort.

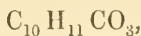
The portion which had been collected between 223° and 226° C. ($433\cdot4^{\circ}$ and $438\cdot8$ F.) was repeatedly redistilled, until a liquid of a constant boiling-point at 226° C. ($438\cdot8$ F.) was obtained, which at $15\cdot5^{\circ}$ C. (60° F.) had a sp. gr. of $0\cdot9065$. When submitted to combustion, it gave the following results :

- I. $1\cdot91$ grains of substance gave :
 $4\cdot60$ „ „ carbonic acid, and
 $1\cdot95$ „ „ water.
 II. $2\cdot05$ „ „ substance gave ;
 $4\cdot90$ „ „ carbonic acid, and
 $2\cdot10$ „ „ water.

Percentage-composition :

	I.	II.
Carbon. . .	$65\cdot68$	$65\cdot12$
Hydrogen. .	$11\cdot30$	$11\cdot31$

These numbers agree pretty closely with the formula,



as may be seen in the following comparison of the theoretical numbers with the results of the experiments :

		Theory.		Mean of the Experiments.
				
11 eqs. Carbon	. .	66	65·34	65·40
11 „ Hydrogen	. .	11	10·89	11·35
3 „ Oxygen	. .	24	23·77	—
		101	100·00	

Carbonate of amyl may be produced by the action of potassium or sodium (the latter metal was indeed employed in most of my experiments) upon oxalate of amyl with great facility, and to any extent ; its preparation in this reaction is not attended with the same difficulties which we experience in performing the experiment in the ethyl-series. The actual process, however, which gives rise to its formation remains still doubtful, although the preceding experiments have furnished a new element for its correct interpretation, namely, the observation of a large quantity of amyl-alcohol being reproduced during the reaction—a reproduction which has escaped notice in the preparation of the carbonic ether *par excellence*, on account of the solubility of the ethyl-alcohol in water.

XII.—*New Formation of Salicylic Acid.*

BY H. GERLAND.

FROM A LETTER OF DR. KOLBE TO DR. HOFMANN.

Mr. Gerland has been lately engaged in my laboratory with a comparative investigation of the three isomeric acids, namely: Zinin's benzanilic acid, Fritzsche's anthranilic acid, and Chancel's carbanilic acid, induced chiefly by the frequently asserted view of these acids being identical.

According to certain theoretical views which I have already

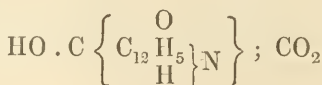
stated,* I considered myself justified in doubting the identity of benzoic with anthranilic acid, it being more probable, however, that anthranilic acid is identical with carbanilic acid, and that it stands in the same relation to carbonic acid as carbamic acid. This assumption is based upon the view that benzoic acid is an oxide of the conjugate benzoyl-radical $(C_{12}H_5)^{\cdot}C_2$, namely, $HO, (C_{12}H_5)^{\cdot}C_2O_3$, that nitrobenzoic acid $HO, (C_{12}\{\frac{H_4}{NO_4}\})^{\cdot}C_2O_3$ contains a secondary benzoyl-radical, in which NO_4 replaces H; and that the nitrobenzoyl of nitrobenzoic acid is converted by treatment of the latter with sulphide of ammonium, into amido-benzoyl of the formula $(C_{12}\{\frac{H_4}{H_2N}\})^{\cdot}C_2$.

Benzoic acid . . $HO (C_{12}H_5)^{\cdot}C_2, O_3$

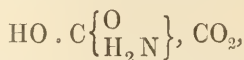
Nitrobenzoic acid $HO (C_{12}\{\frac{H_4}{NO_4}\})^{\cdot}C_2, O_3$

Benzoic acid .
(Amido-benzoic acid) $HO (C_{12}\{\frac{H_4}{H_2N}\})^{\cdot}C_2, O_3$.

According to this view, benzoic acid would be benzoic acid with 1 equivalent of hydrogen in its radical, replaced by 1 equivalent of amidogen, while the isomeric anthranilic acid



has the chemical constitution of carbamic acid



and is only distinguished from the latter by containing anilidogen instead of amidogen.

The experiments performed by Mr. Gerland, which he will shortly communicate in detail, have proved that benzoic and anthranilic acid are in fact distinct acids, and that they not only differ materially in their chemical properties, but also yield under similar influences, perfectly different (sometimes very interesting) products of decomposition.

* Chem. Soc. Qu. J. IV, 73.

While anthranilic acid is always deposited from the hot aqueous solution in needles, sometimes an inch in length, benzoic acid can only be obtained from its hot saturated aqueous solution as an indistinctly crystalline mass. The salts of the two acids exhibit much similarity in appearance; those of benzoic acid are however, generally speaking, much more soluble than the corresponding salts of anthranilic acid.

The difference of the two acids is most clearly shown in their comportment with potash, sulphuric and nitrous acid.

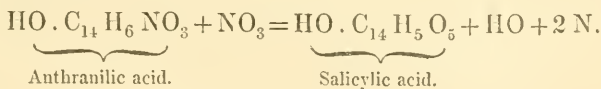
Anthranilate of potash, when heated with hydrate of potash, yields aniline; the benzoate does not yield a trace of this body.

While strong sulphuric acid converts anthranilic acid into sulphanic acid, with evolution of carbonic acid gas; benzoic acid, on the other hand, dissolves in it without evolution of gas, forming a violet solution.

If nitrous acid (prepared by acting on arsenious acid with nitric acid) is passed through a dilute warm aqueous solution of anthranilic acid, till no more nitrogen is evolved, it remains clear, and yields, on evaporation, fine long needles of an acid free from nitrogen, and possessing the composition and properties of salicylic acid.

With salts of sesquioxide of iron it yields the characteristic violet colour produced by salicylic acid, under the same circumstances, and on dry distillation, a considerable quantity of phenol is produced, a portion of the acid subliming unchanged.

The conversion of anthranilic acid into salicylic acid, by means of nitrous acid, which you anticipated in your paper* on the action of nitrous acid on the amidogen-bases, takes place according to the following equation:



A dilute aqueous solution of benzoic acid also undergoes a change when exposed to the action of nitrous acid; not a trace of salicylic acid is, however, formed. An alcoholic solution of benzoic acid, through which nitrous acid is passed, becomes red, then turbid, and deposits a red crystalline body, insoluble in water and alcohol, but readily dissolved by ammonia and potash, which Mr. Gerland is at present examining.

If benzoic acid retains the constitution of benzoic acid (*i. e.* if it

* Chem. Soc. Qu. J. III, 235

is amido-benzoic acid), it is probable that a benzoic acid would be obtained by its decomposition with nitrous acid, in which one equivalent of hydrogen in the radical is replaced by one equivalent of oxygen, namely, $\text{HO}, (\text{C}_{12} \left\{ \begin{smallmatrix} \text{H}_4 \\ \text{O}_4 \end{smallmatrix} \right\})^{-} \text{C}_2, \text{O}_3$.

The results of all experiments which have at present been conducted in this direction would appear to favour this view.

XIII.—*Chemical Memoranda.*

BY ROBERT WARINGTON.

In laying the present short notices before the Chemical Society, I do it with the impression that the example may be useful as a means of registering a great number of very interesting and sometimes important facts and observations, which, taken in their isolated state, would not afford sufficient matter for their being arranged in the form of a paper, and therefore are generally laid aside, and frequently altogether lost to science; whereas, if they were collected and arranged as a series of memoranda, they would serve to occupy profitably a few pages of our Transactions, with useful practical observations, and give rise at the meetings of the Society to much valuable discussion. Under this impression, therefore, I have made bold to endeavour to pioneer the way, in a path which I hope to see followed by many of our working members.

The first memorandum I shall submit to your attention is :

On a curious form of Crystallization of Iodide of Potassium.

In the preparation of this salt on the large scale, crystals are at times obtained presenting a very curious appearance, namely, that of a cubic needle or prism, of considerable length, and of varying diameter, and apparently formed by the superposition of cube upon cube. The specimens to which I would more particularly direct your attention, were procured some years since, and have become much injured and fractured; but sufficient of them remains to demonstrate fully the following details of measurement. Two only of these crystals were selected for this purpose; but I may mention that many similar ones were obtained at the same time as these. The first specimen had a total length of 4.40 inches, which was composed of the following divisions :

At its point of attachment to the general mass of salt, its diameter was :

		$\frac{6}{40}$	of an inch, which continued for	$\frac{3}{40}$	$\frac{2}{0}$	of an inch ; it then
decreased to		$\frac{5}{40}$	„ „ „	$\frac{8}{40}$	$\frac{5}{0}$	„ „
„ „		$\frac{3}{40}$	„ „ „	$\frac{3}{40}$	$\frac{3}{0}$	„ „
„ „		$\frac{2}{40}$	„ „ „	$\frac{1}{40}$	$\frac{6}{0}$	„

where the crystal terminated.

$$\frac{176}{40} = 4.40 \text{ inches.}$$

The second specimen was found to give the following measurements : Its entire length was $2\frac{7}{40}$ of an inch, and the diameter of the cubic needle, at its junction with the rest of the crop, was :

		$\frac{7}{40}$	of an inch, which continued for	$\frac{1}{40}$	$\frac{4}{0}$	of an inch ; it then
decreased to		$\frac{5}{40}$	„ „ „	$\frac{2}{40}$	$\frac{5}{0}$	„ „
„ „		$\frac{4}{40}$	„ „ „	$\frac{4}{40}$	$\frac{8}{0}$	„

$$\text{Total length} \quad . \quad . \quad . \quad \frac{87}{40} = 2\frac{7}{40} \text{ inches.}$$

It will be evident, therefore, that these crystals exhibit certain distinct and strongly marked intervals of decrease in their stages of progression ; and this decrease in the diameter of the cube is sudden and abrupt, forming at that point sharp and well-defined angles, and not passing gradually from one dimension into the other as it elongates. It will be noticed, also, in looking over the measurements, that a perfectly symmetrical cubic arrangement is maintained throughout their whole extent, and that the intervals of length correspond exactly to a multiple of the diameters of the cubes.

These crystals are most frequently obtained when the solutions from which they are deposited are rather alkaline.

MEMORANDUM II.

On a method of detecting, qualitatively, small quantities of Oxide of Copper in solution.

This operation depends upon the solubility of the ferrocyanide of copper in an excess of a solution of ammonia, and its deposition with its well-marked characteristic appearances as the ammonia evaporates. Thus, supposing a frequently occurring case, where the oxide of copper, in very small quantity, is in solution with oxide of iron, and that these metals have been brought to their highest state of

oxidation; ammonia is next added in excess, and then a few drops of a solution of the ferrocyanide of potassium, and the whole thrown upon a filter. As the ammonia escapes from the filtrate by standing, and free exposure to the air, the red ferrocyanide of copper will be deposited, and if the experiment be made in a shallow white porcelain dish, the result will be very distinct and characteristic, and on carefully decanting the fluid, will be found on the white surface. In many cases, the process of filtration may be dispensed with altogether, as the suspended peroxide of iron does not in the least interfere with the deposition of the ferrocyanide of copper from the solution. I have found this test give unerring indications in cases where no trace of blue colour could be distinguished in the ammoniacal solution, and where no precipitation could be procured by hydrosulphuric acid gas or the action of a voltaic circuit.

When organic colouring matter is present, this form of test is also very useful, as in vinegars, &c., and it was in a case of this kind which came under my notice some years since, that I was induced to put it more fully into practice. A party was seeking to recover compensation for the destruction of some valuable meadowlands, from the action, it was affirmed, of the waste waters from some copper mines. These meadows owed their luxuriance, and consequent value, to a periodic inundation by the water from the granite moors of that part of Cornwall. Several copper mines had, however, been opened on these high lands; and from the scarcity of water, it was retained at the mines for some time, being used over and over again for stamping and dressing the ores, until it became, as a natural consequence, highly charged with metallic impurities. In this state it was, at certain intervals of time, discharged in large quantities down the valley, overflowing the banks of the stream and causing the destruction complained of.

The great object, in a chemical point of view, was to trace the cause of the injury into the substance of the injured herbage, the dead grass; and this I found could be readily and satisfactorily accomplished by means of the test now indicated.

Our late respected President, Mr. Phillips, to whom I mentioned this mode of testing some years since, introduced it into his translation of the London Pharmacopœia.

MEMORANDUM III.

Some additional observations on the Green Teas of commerce.

Since the publication of my last communication on this subject, read before the Society on May 19th, 1851, a series of microscopical and chemical examinations have been published* which have induced me to institute some additional experiments, the results of which may not be without interest to some of the members of the Society, particularly as they tend to remove a curious anomaly that has lately arisen. In the series of examinations alluded to, it is stated that several of the specimens of green tea submitted to investigation, were coloured with indigo mixed with porcelain clay; and this is followed by an examination of some of the colouring materials themselves used at Canton for this purpose, and which had been obtained from the museum at Kew Gardens. As I had stated† that, up to that period, no sample in which indigo had been employed as an artificial colouring agent for green teas had come under my notice, I felt it incumbent on me to investigate the matter. For this purpose I applied to Sir W. Hooker on the subject, and he allowed me in the handsomest manner to take from the cases in the museum, small portions of the materials for examination, and also favoured me with the loan of the manuscript Journal of Mr. Berthold Seeman, by whom the specimens had been collected while at Canton, as Naturalist of H.M. ship ‘Herald,’ then on a survey in that quarter of the globe. As these documents have been since published, and as the subject opens some interesting particulars, I have taken the liberty of appending his account in his own words.‡ Mr. Seeman here dis-

* The Lancet, August 9th, 1851.

† Qu. J. Chem. Soc. IV, p. 156.

‡ Hooker’s Journal of Botany and Kew Garden Miscellany, No. 37, for Jan., 1852: “In the ‘Manual of Scientific Inquiry’ you ask whether, in the northern provinces of China, indigo or any other vegetable dye is used in colouring green tea? Whether different processes of dyeing are pursued in the north from those of the south, I cannot say, but it is certain that around Canton, whence great quantities are annually exported, the green tea is dyed with Prussian blue, turmeric and gypsum, all reduced into fine powder. The process is well described by Sir J. F. Davis (‘The Chinese,’ III, 244), who, however, falls into the strange mistake of supposing the whole proceeding of colouring to be an adulteration, and leaves his readers to infer that it is only occasionally done in order to meet the emergency of the demand; while it is now very well known that all the green tea of Canton has assumed that colour by artificial dyeing. I had heard so much about tea, copper-plates, picking of the leaves, rolling them up with the fingers, boiling them in hot water, &c., that I became anxious to see with my own eyes

tinely states, that around Canton the *green tea* is dyed with *Prussian blue, turmeric, and gypsum*; that, in the manufacture he inspected, the *dyes above mentioned* were added; and he gives their proportions. That there was *no concealment* or mysterious proceeding; that one of the great merchants conducted him over his own and also another manufactory, and that everything was conducted openly and exhibited with great civility. And yet, strange to say, Mr. Seeman appears to have been deceived notwithstanding all this; for on submitting these materials to the action of chemical tests, there could be no doubt that they consisted of indigo, of a very inferior quality, and leaving a very large proportion of inorganic matter by calcination, and of porcelain clay. It is also curious that the very case selected by Mr. Seeman to illustrate the processes, is the conversion, by means of this facing or glaze, of a low quality of black tea (Bohea Saushung) valued at about 4*d.* to 6*d.* the pound, into high quality green teas valued at from 1*s.* to 1*s.* 6*d.* the pound; but although Mr. Seeman does not allow this to be an adulteration, yet surely he cannot deny that it is a fraud.

Another very good method which I have lately employed of removing the colouring matter from the surface of green teas for the purpose of microscopical investigation, and one attended with very little trouble, is to take a piece of cream-coloured wove paper, or

the process of manufacture, of which the various books had given me such a confused idea. One of the great merchants conducted me not only to his own, but also to another establishment, where the preparation of the different sorts was going forward. There was no concealment or mysterious proceeding, everything was conducted openly, and exhibited with the greatest civility; indeed, from all I saw in the country, I am almost inclined to conclude that either the Chinese have greatly altered, or their wish to conceal and mystify everything, of which so much has been said, never existed.

"The tea is brought to Canton unprepared. After its arrival it is first subjected to cleaning. Women and children are employed to pick out the pieces of twigs, seeds, and other impurities with which it happens to be intermixed. The only sorts which may be called natural are those gathered at different seasons; the rest are prepared by artificial means.

"Without entering into a description of all these processes, it may suffice to take one as an example. A quantity of Bohea Saushung was thrown into a spherical iron pan kept hot by means of a fire beneath. These leaves were constantly stirred about until they became thoroughly heated, when the dyes above mentioned were added, viz., to about twenty pounds of tea, one spoonful of gypsum, one of turmeric, and two or even three of Prussian blue. The leaves instantly changed into a bluish-green, and, having been stirred for a few minutes, were taken out. They, of course, had shrivelled, and assumed different shapes from the heat. The different kinds were produced by sifting. The small, longish leaves fell through the first seive, and formed Young Hyson, while those which had a roundish, granular shape, fell through last, and constituted Choo-cha, or Gunpowder."

paper free from blue colouring material, and having breathed on its surface or rendered it slightly damp, to pour the sample of tea under examination, from the containing paper or vessel upon it. On then removing it back again, a quantity of the facing powder will be found adhering to the surface of the paper; and on placing it under the microscope, it will be found studded with the colouring materials used, and the blue particles can be subjected to the action of chemical tests with the greatest ease, by placing a minute drop of the reagent on the granules with the end of a small stirring rod, or slip of glass, and noting the effect.

MEMORANDUM IV.

A modification of the ordinary process of sublimation in a straight tube.

In examining the blue colouring material used for green tea taken from the Kew Museum so as to demonstrate its being indigo, I was led to try a modified arrangement in the ordinary method of using the straight tube for sublimation. It consists simply in introducing the material to be examined into a small capillary tube, of such an external dimension that it can be easily passed into the interior of another tube, which should be of hard white glass. By this means the substance can be placed over whatever part of the external tube the operator may desire, at the same time avoiding any risk of soiling the part of the external tube on which the sublimate is to be condensed, and with the power of withdrawing the material at any time for the removal of condensed moisture, or only matter, as also of shifting its position during the operation. The experiment being completed, the internal tube is withdrawn, and both the fixed residue and the volatile constituents can be readily submitted to chemical agents, or put by for future investigation.

I have since employed this arrangement in various other cases, as in the detection of arsenic and corrosive sublimate in cases of poisoning, with complete success.

XIV.—*On the Action of Ammonia upon Binoxysulphocarbonate of Amyl.*

BY MATTHEW W. JOHNSON,

ASSISTANT IN THE LABORATORY OF ST. BARTHOLOMEW'S HOSPITAL.

Chemists are acquainted with the singular compound which M. Desains obtained by the action of iodine upon xanthate of potash, and described under the somewhat lengthy name of binoxysulphocarbonate of ethyl. They likewise recollect the experiments of M. Debus, who submitted this compound to the action of ammonia, in order to obtain, if possible, a more definite view regarding its constitution, which is still open to discussion. These experiments led to the discovery of a new substance, which M. Debus terms xanthamide, and which is formed in this reaction, together with xanthate of ammonia. The corresponding term in the amyl-series being still unknown, Dr. Hofmann suggested to me the preparation and study of this substance, while at the Royal College of Chemistry, in the laboratory of which Institution, the experiments about to be described were carried out.

In preparing binoxysulphocarbonate of amyl, Desains' process, slightly modified, was successfully employed. To hydrate of potash, crushed to a coarse powder in a mortar, fusel-oil and excess of anhydrous bisulphide of carbon are added, and the mixture triturated until a soft yellow mass results. A small quantity of a red oily liquid is generally found disseminated through it.

Amyloxanthate of potash thus prepared, is placed in a flask with bisulphide of carbon, sufficient in quantity to convert it into a very thin paste. Iodine is then introduced, which is immediately decolorized, with evolution of heat. On agitation, a grey mixture is formed, consisting of roundish granules of iodide of potassium, and a yellow mobile liquid. The whole, thrown on a filter, and washed with bisulphide of carbon, yields a filtrate, which, on distilling off the bisulphide of carbon, leaves the binoxysulphocarbonate of amyl, a yellow oily liquid, which is thus prepared, in considerable quantity, with the greatest ease, and sufficiently pure.

This compound was treated with ammonia, in order to obtain the substance corresponding to M. Debus's xanthamide. The plan which first suggested itself, was to pass dry ammoniacal gas through an alcoholic solution of the substance, and to separate the amide from the ammoniacal salt simultaneously generated, by evaporating

to dryness, and exhausting by means of ether, a mode of separation quite successful with regard to xanthamide. This method, however, failed, from the fact that the new compound produced in this reaction, which I shall designate by the term *Xanthamylamide*, is only slightly more soluble in ether than the accompanying ammonia-salt, which, as proved by subsequent analysis, was amyloxanthate of ammonia. The process finally adopted, was to digest the binoxysulphocarbonate of amyl with a concentrated aqueous solution of ammonia, at a slightly elevated temperature. In the course of a few minutes the mixture becomes turbid, sulphur is deposited, and a yellow liquid, through which oily particles are seen suspended, floats above. Four or five hours suffice to accomplish the reaction. When 1 part, by bulk, of binoxysulphocarbonate of amyl is treated with 3 parts of ammonia, a semi-solid mass results. This mass, diluted with water, and thrown upon a moistened filter, affords a clear yellow filtrate mixed with a few oily globules, which, however, on refiltration, are completely separated. The oily liquid retained by the filter is now to be well washed with water, which dissolves the amyloxanthate of ammonia, leaving behind the xanthamylamide with the sulphur. This mixture, which has completely separated from amyloxanthate of ammonia, is freed as much as possible from water, and passed through a dry filter, which retains the sulphur. A transparent, pale-yellow oily liquid, is now obtained, which, for the purpose of desiccation, is placed *in vacuo* over sulphuric acid for some time, and, finally, a current of dry carbonic acid gas is passed through the liquid, a gentle heat being at the same time applied.

The xanthamylamide, thus prepared, was analysed. The numbers obtained were, however, only approximative, because the substance could not be freed entirely from impurities, the method of preparing, not excluding small quantities of fusel-oil, and even water, purification by distillation being impossible, because the compound is decomposed under the influence of heat. The substance was analysed in the ordinary manner with chromate of lead, a binoxide of lead tube being used between the chloride of calcium tube and the potash bulbs, to retain any sulphurous acid. The sulphur was determined by ignition in a combustion tube, with a mixture of carbonate of soda, nitrate of potash, and chlorate of potash.

The following results were obtained :

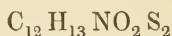
- I. 0.1920 grm. of substance yielded :
0.3460 „ „ carbonic acid,
0.1781 „ „ water.

II.	0.2290	gram.	of substance gave :
	0.4150	„ „	carbonic acid,
	0.2025	„ „	water.
III.	0.2520	„ „	substance gave :
	0.3889	„ „	sulphate of baryta.
IV.	0.2825	„ „	substance gave :
	0.4259	„ „	sulphate of baryta.

These numbers lead to the following percentages :

	I.	II.	III.	IV.
Carbon .	49.11	49.38	—	—
Hydrogen	10.27	9.82	—	—
Sulphur .	—	—	21.15	20.67

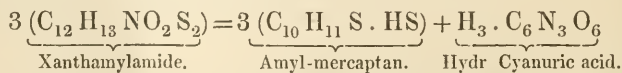
The formula



constructed from analogy, requires the following values :

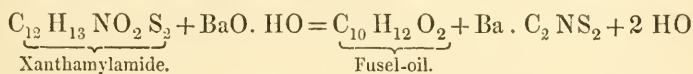
		Theory.	Mean of Experiments.
12 eqs. Carbon . .	72	48.98	49.24
13 „ Hydrogen . .	13	8.85	10.04
1 „ Nitrogen . .	14	9.52	—
2 „ Oxygen . .	16	10.88	—
2 „ Sulphur . .	32	21.77	20.91
		147	100.00

All my attempts to distil this compound, without at the same time decomposing it, failed. When the temperature rose to 184°C . the liquid boiled, oily drops distilled over, and a strong smell of amyl-mercaptan was noticed. The distillate, dissolved in alcohol, gave a copious white precipitate with protochloride of mercury. The dark-grey residue in the retort, boiled with water and filtered, afforded a liquid which, evaporated to a small bulk, and stirred rapidly, deposited, when cold, an adherent, granular, fawn-coloured precipitate of cyanuric acid. A small quantity, dried and heated in a tube, emitted the peculiar suffocating vapour of cyanic acid. This change is represented by the following equation :



When heat is applied to a quantity of the amide on platinum foil, it emits copious white fumes, and burns with a luminous yellow flame.

Xanthamylamide is insoluble in water, but very soluble in alcohol and ether. It is neutral to test-paper. It is decomposed, when boiled with *hydrate of baryta*; an oily liquid, having the odour of fusel-oil, distils over; ammonia is disengaged at the same time; and the barytic mixture yields with hydrochloric acid and sesquichloride of iron a deep red liquid, indicating the presence of a sulphocyanide.



The same reaction takes place with *potash*. *Sulphuric acid* in the cold dissolves it, but on dilution, the mixture becomes turbid from separation of oily particles. When heat is applied, sulphurous acid is evolved, and carbonization ensues. Fuming *nitric acid* acts violently upon it, with copious evolution of red fumes; the resulting solution is rendered turbid by dilution, and oily globules rise to the top. Concentrated *hydrochloric acid* does not appear to act upon it, even on boiling. *Chlorine-water*, however, immediately attacks it, giving rise to a volatile oily liquid; sulphur is at the same time deposited. *Iodine* merely dissolves in xanthamylamide, in the cold, forming a red liquid, which, however, on the application of heat, is quickly decolorised, and a colourless oil, soluble in alcohol, separates. *Bromine* is immediately decolorised by xanthamylamide, a white solid mass resulting, which furnishes, with alcohol, a milky liquid; water now eliminates a colourless oil.

Alcoholic solutions of *acetate of lead*, *chloride of copper*, and *nitrate of silver* are not precipitated by an alcoholic solution of xanthamylamide. An aqueous solution of *bichloride of platinum* however, furnishes a copious yellow precipitate, having a faint, peculiar odour, and slightly soluble in alcohol, which deposits, on evaporation, a yellow crystalline compound. The mother-liquid from these crystals quickly becomes brown, and, on evaporation, leaves an amorphous brown residue, copious fumes of hydrochloric acid being evolved at the same time. When an alcoholic solution of bichloride of platinum is employed instead of an aqueous one, perfect solution of the substance results, and, on evaporation, a red crystalline compound is deposited. From the filtrate, a definite substance can no longer be obtained. Neither potash nor hydrochloric acid appears to affect this platinum-compound.

Xanthamylamide forms a perfectly definite compound with *protochloride of mercury*. When a drop or two of an alcoholic solution of this salt is added to an alcoholic solution of the amide, merely a faint turbidness occurs; on increasing the proportion of the former,

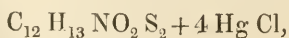
however, until it is present in considerable excess, a copious white precipitate falls, consisting of minute feathery crystals of the mercury-compound; and this, when washed with cold alcohol, in which it is scarcely soluble, and dissolved in a large quantity of boiling alcohol, deposits the substance, on cooling, in a pure state. The pure compound thus obtained was analysed. The carbon was determined by combustion with chromate of lead, the binoxide of lead tube being employed in Experiment III.; in the same experiment the mercury was determined together with the carbon and hydrogen. The mercury was estimated in the other two experiments by decomposing the substance with a mixture of quick-lime and dry carbonate of soda in a current of carbonic acid, and collecting the mercury in a receptacle formed of the anterior part of the combustion tube. In Experiment V. this operation was combined with the German process for the determination of nitrogen.

- I. 0·3865 grm. of mercury-compound, dried *in vacuo*, gave :
 0·1565 „ „ carbonic acid, and
 0·0675 „ „ water.
 II. 0·4132 „ „ mercury-compound gave :
 0·1615 „ „ carbonic acid, and
 0·0820 „ „ water.
 III. 0·3898 „ „ mercury-compound gave :
 0·1448 „ „ carbonic acid,
 0·0720 „ „ water, and
 0·2250 „ „ mercury.
 IV. 0·3645 „ „ mercury-compound, dried in a water-bath,
 afforded :
 0·7970 „ „ mercury.
 V. 0·7150 „ „ mercury-compound yielded :
 0·4160 „ „ mercury, and
 0·1700 „ „ bichloride of platinum and ammonium.

From these numbers the following percentages are deduced :

	I.	II.	III.	IV.	V.
Carbon . .	11·02	10·65	10·13	—	—
Hydrogen .	1·94	2·20	2·05	—	—
Nitrogen . .	—	—	—	—	1·48
Mercury . .	—	—	57·72	58·40	58·18

The simplest atomic expression of these percentages is the formula :



which require the following values :

		Theory.		Mean of Experiments.
12	cqs. Carbon . .	72·00	10·45	10·60
13	„ Hydrogen . .	13·00	1·89	2·06
1	„ Nitrogen . .	14·00	2·03	1·48
2	„ Oxygen . .	16·00	2·32	—
2	„ Sulphur . .	32·00	4·64	—
4	„ Mercury. .	400·28	58·07	58·06
4	„ Chlorine . .	142·00	20·60	—
		689·28	100·00	

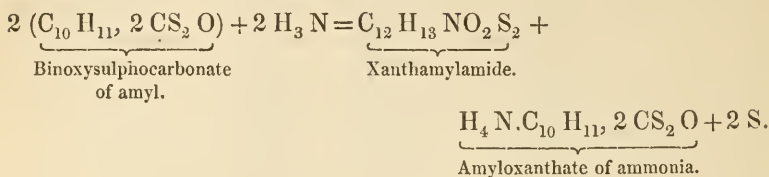
This mercury-compound is insoluble in water; it gradually decomposes, however, if kept for a considerable period in contact with it, an odour of fusel-oil becoming perceptible. It is but slightly soluble in either cold alcohol or ether; its solubility, however, is increased on boiling. Cold concentrated sulphuric acid causes an immediate evolution of hydrochloric acid, and elevation of temperature, attended with blackening. Nitric acid acts with energy upon it. Cold hydrochloric acid has no effect upon it; but, on boiling, a portion of the chloride of mercury is dissolved out, and another mercury-compound formed, containing a smaller amount of the chloride than the original compound; it is a white, soft, solid substance, adhering with great tenacity to the sides of the vessels, and, when heated, melts into a white, opaque oil.

On boiling the mercury-compound with potash, a black precipitate is obtained, and an odour of fusel-oil becomes perceptible. Concentrated ammonia, in the cold, immediately decomposes it, with formation of black protosulphide of mercury. Baryta likewise decomposes it on boiling, with evolution of an aromatic volatile compound, protosulphide of mercury remaining behind.

An attempt was made to prepare a quantity of pure xanthamylamide by decomposing the mercury-compound with hydrosulphuric acid, but it proved a failure—an oily liquid being obtained, which obstinately retained the hydrochloric acid generated in the reaction; no indication of crystallization was observed. The compound separated is, however, doubtless xanthamylamide.

The analysis of the oily product produced by the action of ammonia upon binoxysulphocarbonate of amyl, its products of decomposition, and the examination of the mercury-compound which I have just now described, establish beyond any doubt the existence in the amyl-series of a substance homologous with the xanthamide of the ethyl-

series. The formation of this body is represented by the following equation :



It now remains only to prove, by direct experiment, that the salt produced, together with xanthamylamide, is actually amyloxanthate of ammonia. This salt crystallises from an alcoholic or ethereal solution, in long colourless prisms, which, when cautiously heated between two watch-glasses, give a beautifully crystallised sublimate. It is gradually decomposed by water; a cold aqueous solution, however, may be obtained, which will deposit prismatic crystals on evaporation *in vacuo*; but the presence of a large quantity of water invariably gives rise to an oily liquid—a product of decomposition. When evaporated in the water-bath, the salt volatilises with the vapour of water. Exposure to air decomposes this salt even when dry, one of the products of decomposition being invariably sulphocyanide of ammonium. The yellow oil which separates at the same time, on being washed with water and dissolved in alcohol, does not afford a crystalline compound with bichloride of platinum, which suffices to distinguish this substance from xanthamylamide.

An attempt to purify the salt by gently heating it in a current of dry air, with a view to sublimation, proved fruitless; it rapidly decomposed; white fumes appeared, which condensed to colourless and yellow globules; the yellow colour of the salt deepened in tint; when, suddenly, brisk chemical action was set up in the mass, attended by copious effervescence, and the whole changed at once into a turbid yellow fluid, a strong evolution of sulphide of ammonium vapour accompanying the reaction. On dissolving the mass in water, a solution containing sulphocyanide of ammonium was obtained, on which drops of fusel-oil floated.

Caustic potash added to an aqueous solution of the salt under examination, causes the evolution of ammonia, even in the cold, and copiously when heated. Hydrochloric acid separates from it a volatile oily acid of a suffocating odour and insoluble in water. Nitrate of silver gives a yellow curdy precipitate; acetate of lead, an adhesive, yellow, semi-solid salt, which gradually decomposes and becomes brown. These observations are sufficient to characterize

amyloxanthate of ammonia in an unmistakable manner; nevertheless I thought it desirable to fix, by a number, the formation of this salt, in the decomposition which binoxysulphocarbonate of amyl suffers under the influence of ammonia; and, as amyloxanthate of ammonia could not be obtained sufficiently pure for direct estimation, I selected the lead-salt for analysis. To prepare this compound, a concentrated aqueous solution of the ammonia-salt was mixed with a large quantity of alcohol, and added to an alcoholic solution of acetate of lead until a precipitate began to appear; alcohol in excess then afforded a clear solution, which, on spontaneous evaporation, deposited delicate shining plates of amyloxanthate of lead, which were washed with alcohol, dried, and submitted to analysis:

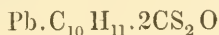
0.2790 grm. of the lead-compound gave

0.1565 „ „ sulphate of lead,

corresponding to

38.32 per cent of lead.

Amyloxanthate of lead:



requires

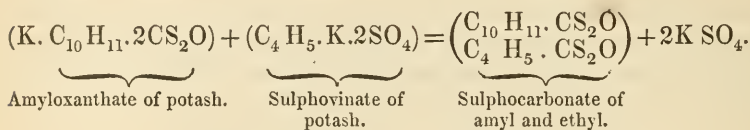
38.85 per cent of lead.

On dissolving amyloxanthate of potash, prepared by the ordinary process in alcohol, and adding an alcoholic solution of acetate of lead, a salt was obtained having all the properties of the above compound. Incidentally to the preceding investigation, a few experiments were made with the acid separated by sulphuretted hydrogen from the amyloxanthate of lead. This salt, freshly made, was quickly washed with cold water, suspended in alcohol, and treated with hydro-sulphuric acid gas; and the colourless liquid separated by the filter from the sulphide of lead was warmed until the free sulphuretted hydrogen was dissipated. It then possessed an acid reaction, which chloride of barium showed was not owing to sulphuric acid, as it gave no precipitate. It gave a yellowish-white crystalline precipitate, however, with an alcoholic solution of acetate of lead, and potash gave rise to the crystalline potash-salt. Evaporation left a liquid highly acid to test-paper, and farther evaporation caused the evolution of white suffocating fumes.

According to a statement of M. Chancel,* the distillation of a mixture of xanthate of potash and sulphomethylate of potash gives

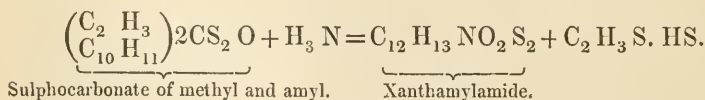
* Comptes Rendus, April 21st, 1851.

rise to a compound which he terms sulphocarbonate of ethyl and methyl, and which, under the influence of ammonia, is converted into semi-sulphuretted urethane, or xanthamide, and methyl-mercaptan. This statement induced me to institute a few experiments with a view to procure xanthamylamide by analogous means. For this purpose, I prepared the sulphocarbonate of amyl and ethyl, by distilling a mixture of amyloxanthate of potash and sulphovinate of potash :



The distillate, which consisted of a yellow aromatic liquid floating above a colourless one, was digested for several days with concentrated ammonia. A yellow-coloured mixture resulted, which emitted the odour of amyl-mercaptan. I was, however, unable to obtain positive proof of the formation of xanthamylamide. I was more fortunate with regard to the analogous sulphocarbonate of methyl and amyl. This compound, when heated with dry ammoniacal gas, and digested with it for several months, gave rise to a substance which possessed all the properties of xanthamylamide; the quantity obtained, however, was too small to admit of an analysis.

The formation of xanthamylamide in this reaction is represented by the equation :



I cannot conclude without publicly acknowledging the kind advice and assistance of Dr. Hofmann during the prosecution of this investigation.

XV.—*On a New Process for the Detection of Fluorine when accompanied by Silica.*

BY GEORGE WILSON, M.D.

Having had occasion recently to examine several substances containing a small amount of fluorine, along with a large amount of silica, I have put in practice two processes, one of which is so easily managed, and has yielded such excellent results, that I bring it before the attention of the members of the Chemical Society.

The substances which I had to examine were the ashes of straw, hay, coal, and charcoal; and likewise granite, basalt, greenstone, and clinkstone, in the majority of which, fluorine has not hitherto been detected, nor, indeed, sought for, owing, doubtless, to the practical difficulties which attend the detection of fluorine when accompanied by much silica. The chief difficulty in such inquiries arises from the necessity of carrying on the analysis in vessels of platinum, which makes it impossible to subject large quantities of material to investigation.

The following process meets this difficulty, as it requires only the ordinary glass and porcelain vessels of the laboratory, and may be prosecuted with any amount of material. It is founded upon the very familiar fact, that when a fluoride, combined or mixed with silica, is heated with oil of vitriol, the fluorine and silicon are evolved in combination, as the well-known fluoride of silicon (SiF_3); and it is applicable to all silicated fluorides which yield this gas. It is further applicable to compounds containing mere traces of fluorides, but free from silica, which are brought within the compass of the process, by the deliberate addition of silica to them, so as to admit of their being heated in large quantity with oil of vitriol in glass vessels. In either case, the fluoride of silicon set free is conveyed by a bent tube from a flask or retort into water. The resulting solution, containing some gelatinous silica, is supersaturated with ammonia, and evaporated to dryness, during which process the fluoride of silicon and ammonium ($2 \text{SiF}_3 + 3 \text{NH}_4 \text{F}$) is resolved into silica, which is rendered insoluble, and fluoride of ammonium, which is dissolved by digesting water on the evaporated residue. The solution of the ammonio-fluoride is then evaporated to dryness, and heated with oil of vitriol, in a platinum crucible, covered by a piece of waxed glass, having lines traced through it, so as to permit the hydrofluoric acid evolved to etch the glass. I have tried this process

with Peterhead and Aberdeen granite, with basalt from Arthur's Seat, greenstone from Corstorphine Hill, and clinkstone from Blackford Hill—all three in the neighbourhood of Edinburgh. I have also tried it with the ashes of barley-straw, of hay, of coal, and of charcoal; and in addition with a fossil bone, containing much carbonate of lime, and with a deposit from the boiler of an ocean steamer. To the bone and to the boiler deposit, pounded glass was first added. I lay before the Society some of the specimens obtained in this way. They are not selected successful ones, but represent the earliest trials. Where the rocks under examination have been weathered, or the substances (such as plant-ashes) have contained salts of volatile acids (for example, chlorides and carbonates), I have treated them first with oil of vitriol in the cold, so as to evolve hydrochloric acid and carbonic acid. On afterwards raising the liquid to the boiling-point, in a flask with a bent tube, a gas was given off, if fluorine were present, which deposited gelatinous silica when passed through water, and produced with it a solution which gave a gelatinous precipitate with potash. The whole of the fluoride of silicon is given off as soon as the oil of vitriol has reached its boiling-point. I am at present engaged in applying this process to a variety of substances, and in ascertaining its applicability to the quantitative determination of fluorine. I forbear, in the meanwhile, to enlarge upon the interesting geological, mineralogical, and physiological results which may be expected to flow from the discovery of fluorine in trap rocks, and the recognition of its comparative abundance in plants.

PROCEEDINGS
AT THE
MEETINGS OF THE CHEMICAL SOCIETY.

Anniversary Meeting, March 30, 1852.

PROFESSOR DAUBENY, President, in the Chair.

The following Annual Report was read by the President.

Gentlemen,

The Twelfth Anniversary of this Society, which we are to-day assembled to celebrate, opens under circumstances peculiarly auspicious, suggesting to us matter for congratulation as to the past, and for encouragement with respect to the future.

Our body has already, by the number of its members, by the value of its contributions to science, and by the increasing interest testified in its proceedings, vindicated to itself a full claim to the place which, under the presidency of Mr. Brande, it had acquired amongst the chartered scientific societies of the metropolis; and is now, moreover, I am happy to add, established in a locality more worthy of its high position, and capable of affording those accommodations for the reception of its members and for the display of its library and of its collections, of which it has long felt the want.

The advantages of the present abode need not indeed be particularized in addressing members, upon the recollections of most of whom the deficiencies of our former locality must be vividly impressed; nor could they have been secured at a more fortunate moment than the present, when they enabled us to accommodate that large assemblage of chemical products which were so liberally contributed by various individuals at the close of the Great Exhibition of last year.

In consequence of these donations, we may indeed flatter ourselves

that the Chemical Society will hereafter be resorted to, not only as the spot where the newest discoveries in this department of science may be expected to be announced, and the most authentic information on the existing state of our knowledge on such subjects obtained; but also as the depository of all that is curious and important amongst the natural or artificial productions, which may from time to time be elaborated through the instrumentality of chemical processes. And when we recollect how difficult and how toilsome, even in expert hands, the preparation of many of these compounds is found to be, how little there is to induce the mere manufacturing chemist to exercise his skill upon them, and how unprofitable it would be for the most assiduous cultivator of the science to obtain by his own unassisted labours any considerable number of the multifarious combinations which art is capable of bringing about between the elements of matter, the utility of such a depôt for the reception of such presents, as we are now attempting to form, cannot perhaps be too highly appreciated.

Each of the substances, indeed, stored up within our cases, may be regarded as a standard with which to compare any new body lighted upon in the progress of chemical investigation, and thus as not only aiding directly in the advancement of science, but also in the prevention of much unnecessary labour, by pointing out what has already been ascertained in each department of inquiry. I may, therefore, take upon myself to congratulate the Society most warmly on the progress that has been made towards the formation of a Chemical Museum, and to point out as one of the incidental benefits flowing from the Great Exhibition of last year, that it has been the means of affording such ample contributions to that treasury of scientific products, which it is our pride to possess.

I should, indeed, have deemed the acquisition of a place in which these advantages might be secured, as a worthy object upon which to expend a portion of our reserved funds, had the general interests of science alone been consulted in this appropriation of them; but there was also reason to hope that every addition to our means of imparting knowledge would be followed by a greater disposition on the part of the public to avail itself of them; and hence that these increased facilities would be followed by a proportionate augmentation in the number of our members. And although the influence of these changes will be more felt hereafter, yet I am happy to report that already the increase which has taken place in our members, is such as to show that this anticipated result has, to a certain extent, been realised.

It appears, from the Secretary's Report, that there have been elected since the last Anniversary Meeting, 24 members, whilst the deaths and resignations together amount only to 8; showing an increase over last year of 16, from which number, however, might perhaps be deducted 2, who have suffered the time to expire within which the payment of the entrance-fee should have been made, and whose election is consequently void.

According to this calculation, the actual number of Fellows will be 243; whereas, at the last Anniversary Meeting, it was only 229, showing that the steady though slow increase in our number, which had been remarked on former anniversaries, still continues.

STATEMENT OF THE NUMBER OF FELLOWS OF THE CHEMICAL SOCIETY
AT THE PRESENT TIME, AND AT THE CORRESPONDING PERIOD OF
LAST YEAR.

Present number of Fellows	245
Elected since last Anniversary Meeting	24
Deaths and resignations since last Anniversary Meeting	8
	—
Increase since last Anniversary Meeting	16
Number of Fellows at period of last Anniversary Meeting	229

T. REDWOOD,

Secretary.

March 22, 1852.

The three Fellows whom we have lost by death since our last Anniversary, are Mr. Richard Phillips, Mr. William West, and Mr. Henry Beaufoy.

The first of these gentlemen had vacated the office in this Society in which I had the honour to succeed him, only a short time, when he was seized by an attack of bronchitis, which quickly terminated an useful and busy life, mainly dedicated to the investigation of physical truth.

Mr. Richard Phillips and his elder brother William, who died several years ago, were the sons of a printer, in George Yard, Lombard Street, a member of the Society of Friends.

The elder brother was distinguished as a crystallographer and as a mineralogist, in which capacities, as well as by his compilations in geology, he aided materially the early progress of that science. The

younger, educated as a druggist, under the late Mr. William Allen, of Plough Court, became at least equally distinguished for his acquirements in Chemistry.

His reputation, indeed, in this line, secured to him at an early age the honour of a place in the Royal Society, and caused him also to be elected as an honorary member of the Medico-Chirurgical Society, thus bringing him into intimate connexion, on the one hand, with the chemical philosophers, and on the other, with the physiologists and physicians of the age.

He might indeed be regarded, during the latter part of his life, as a connecting link between the chemists of the last generation and of the present, having been the contemporary of Davy and Wollaston, no less than of Faraday and Graham; and in his death we have lost one of the last of that distinguished band of philosophers, who, before chemical science had so enlarged its boundaries, as to include within its domain and to comprehend within the operation of its laws the products of animal and of vegetable life, occupied themselves almost exclusively in the investigation of the combinations of which mineral bodies are susceptible.

Mr. Phillips' labours in this latter department were characterized by great neatness and precision; so that they may indeed be appealed to at the present time as models of skilful and exact research. To him we are indebted for the first correct analyses of the Bath waters, in the course of which investigation he discovered the cause of the apparent uncertainty in the indications afforded by the common tests for iron, caused by the variations that occur in their effects, according as carbonate of lime is present or not.

This was followed by an examination of other celebrated mineral springs, and by that of several rare minerals, one of which relates to his discovery of phosphoric acid combined with uranium,* a fact which had escaped the searching eyes of Berzelius, who was thus as much outdone in the above particular by the subject of this notice, as Davy had been by him when he detected the presence of phosphoric acid in Wavellite, which the great English chemist had overlooked.

By this and other of his contributions to science, Mr. Phillips so raised his reputation, that he was pronounced by Dr. Thomas Thomson, in his Chemistry, the first of modern analytical chemists.

It was, however, in the pharmaceutical branch of the subject that his services were most conspicuous, as might be expected from one of his acuteness, after a training in the above-mentioned establish-

* Annals of Philosophy for 1823.

ment in Plough Court, of which the chemical reputation ranked justly so high.

Indeed, the perfect familiarity he possessed with the processes in use, enabled him to detect the errors into which the framers of our London Pharmacopœia had fallen; whilst the keenness of his reviews gave currency to his censures, of which even those who smarted under their severity, could scarcely help acknowledging the justice. Accordingly, at a subsequent period, he was especially consulted on the drawing up of two of the editions of the London Pharmacopœia by the College of Physicians itself, whose previous labours in that department he had so severely criticised, and thus led the way to many of the much needed corrections in the processes since introduced.

Indeed, during the latter part of his life, he was appealed to as perhaps the highest living authority in this branch of chemistry; and his translation of the London Pharmacopœia, the last edition of which he was engaged at the time of his death in superintending, was looked upon as the best book of reference on all chemical questions involved in the preparation of medicines.

From the year 1821, Mr. Phillips conducted the *Annals of Philosophy*; and when that periodical was incorporated with the London, Edinburgh and Dublin Philosophical Magazine, his services were secured as one of its editors, a post he held till his death.

For this office he was well qualified, from the frankness and friendliness of his character, no less than from his acuteness of intellect, which enabled him to subject the scientific communications which came before him to that rigid scrutiny, which the promulgator of every new view and original fact must be prepared to encounter, before either the one or the other receives the stamp of public recognition, and can be admitted as a part of the common patrimony of science.

Mr. Phillips was successively Lecturer on Chemistry at the London Hospital; at the Government Military College, at Sandhurst; at Mr. Grainger's School of Medicine, in Southwark; and at St. Thomas's Hospital. In 1839, he was appointed Curator of the Museum of Practical Geology, now in Jermyn Street, an office which he continued to hold till the date of its formal opening, under the auspices of H.R.H. Prince Albert, in July last, on the very day before which, he breathed his last, at the age of seventy-two, after a short illness.

Although I was not myself fortunate enough to be frequently thrown into his society, I had seen enough of him to be persuaded of

the truth of the character given of him by his intimates, who describe him as not less remarkable for his ready power of repartee, and keen sense of the ridiculous, than for the quickness of observation, range of knowledge and precision of intellect, by which he was publicly distinguished.

Mr. William West was born at Wandsworth, in the year 1793, of parents, both of whom were members of the Society of Friends.

In the year 1816, he established himself as a druggist, at Leeds, where he became quickly distinguished by his exemplary diligence and unremitting attention to the scientific as well as to the commercial part of his business.

His spare moments were mostly occupied in the study of the most recent discoveries in chemistry, in analytical researches, and in the preparation of the various papers which he contributed to different scientific societies. Of these, no less than twenty-three may be enumerated which were read before the Leeds Philosophical and Literary Society; and these were not only of a kind connected with his own professional pursuits, but also related to various other departments of science and literature. He took an active and prominent part in the foundation of the above-named society, of which he became successively the Honorary Secretary, the Vice-President, and the President.

He also interested himself warmly in the Leeds Mechanics' Institute, and was Vice-President of the Geological and Polytechnic Society of the West Riding of Yorkshire, to which he contributed various papers. On the 1st of March, 1842, he was elected an Associate of the Institute of Civil Engineers, and was awarded the Telford Medal, on the 9th of December, 1846, for a paper "On Water for Locomotive Engines." He was also elected a Fellow of the Royal Society, on the 19th of February, 1846. Mr. West was Chemical Lecturer to the Leeds School of Medicine, from the year 1831 to 1846, when ill-health compelled him to resign this post, as from the same cause he soon after did the commercial part of his business, though still continuing to be engaged in analyses and in scientific investigations of a judicial kind, in which his authority was much esteemed, up to the period of his decease, which took place on the 10th of September, of last year.

My own acquaintance with Mr. West dates as far back as the period, when he formed with myself one of that little band of promoters or cultivators of science, who, obedient to the summons of Sir David Brewster, assembled at York, in the year 1831, and

whilst there, in spite of the smallness of our numbers (which, however, besides the illustrious philosopher who first projected the Meeting, included the names of Dalton, of Murchison, of Forbes, and of Sowerby), had the boldness to organise the scheme of that great scientific association, which next year obtained its full development at Oxford, and has since been welcomed in almost every large city of the British dominions.

The last time I saw Mr. West, was at the meeting of this same body, which took place last year at Ipswich, when he exerted himself to persuade the General Committee to fix upon his native town for their place of meeting in the year 1854, although, with a consciousness of declining health, which the event has shown to have been but too well founded, he declared his persuasion that he should not be alive at the time to welcome us himself.

The late Mr. Henry Beaufoy, of South Lambeth, passed his time in such complete seclusion from the routine of society, that there are very few particulars to relate respecting him.

He was educated for many years under Dr. Goodenough, at Ealing School, which well accounted for his classical attainments and the literary predilections he preserved throughout life. When, however, on the death of his elder uncle, it was considered necessary by the family that he should become a mercantile man, Henry Beaufoy, under the guidance of Mr. Nicholson of Soho Square, gave his attention to practical chemistry, which eventually enabled him to conduct with success a large manufactory, by causing him to appreciate and adopt some modern improvements in science, of great value to his trade.

Deeply grateful as he was to that Providence which had bestowed on himself and all his father's children so many blessings, he considered it an act of duty to prove his gratitude while living, by appropriating a large portion of his income to charitable purposes. Of the extent of these acts of munificence, the following statement may convey a brief, although a very inadequate representation. To the City of London School alone, he appears to have been a benefactor to the amount of £10,000. Then he had established four scholarships for four students, at Cambridge, and had instituted various prizes for the best essays, and for other purposes. Amongst the rest was £1,000 to encourage the study of Shakspeare, the interest to be given away to the most deserving candidate upon the anniversary of the poet's birthday, which chanced to coincide with his own.

Mr. Henry Beaufoy was the eldest son of Colonel March

Beaufoy, well known for his elaborate nautical and hydraulic experiments, the results of some of which, the subject of this notice published in a handsome quarto volume. The entire impression of this work, comprising I believe no less than fifteen hundred copies, he, with his accustomed liberality, distributed gratuitously amongst scientific men and societies, thus performing at once a public service and an act of filial duty.

He was born on the 22nd of April, 1786, died on the 12th of July, 1851, and lies buried in Norwood Cemetery, in the same grave with his wife, as a monument to whom, he had erected, at his own expense, at Lambeth, a very handsome building for a ragged school, which he established and endowed most liberally.

The Papers that have been read at our Meetings since the last Anniversary are by no means inferior either in number or in interest to those of preceding years. I shall not pretend, however, to do more than just to present to you a list of their titles, which are as follows :

Papers read at the Meetings of the Chemical Society, from April 7th, 1851, to March 15th, 1852, inclusive.

“On the Composition of the Water of the Dee and the Don at Aberdeen, with an investigation into the action of Dee-water on lead pipes and cisterns.” By John Smith, M.D., Fordyce Lecturer on Agriculture, and Assistant in the Chemical Laboratory of Marischal College.

“On a peculiar property of Ether and some Essential Oils.” By Dr. C. F. Schönbein.

“On the Analysis of the Sediment deposited from the River Nile, in Lower Egypt.” By Matthew W. Johnson.

“Notice of a Specimen of Chlorobromide of Silver, from Chili.” By Colonel Philip Yorke.

“On the Tests for Nitrates, and a New Test for Nitrites.” By David S. Price, Ph. D.

“On a New Test for Iodides.” By the same.

“Analysis of Milk.” By John Ellis Roberts.

“Observations on the Teas of Commerce.” By Robert Warington.

“On the Composition and Properties of the Carbonates of Lead, constituting the White Lead of Commerce.” By J. A. Phillips.

“On the Equivalent of Phosphorus.” By Professor Schrotter.

"Note on a case of Leakage in a Leadcn Water-cistern." By J. H. Gilbert, Ph. D.

"On Dibenzoylimide, a new derivative of Oil of Bitter Almonds." By Joshua H. Robson.

"On Chromic Acid and Sesquioxide of Manganese." By J. Adam Fairie.

"On the Chromate of Ammonia." By the same.

"On Etherification." By Professor Williamson.

"On the Valuation and Composition of Protochloride of Tin." By Professor Penny.

"On the Chemical Examination of the Metals and Alloys known to the Ancients." By J. Arthur Phillips.

"Observations on the Phenomena of Animal Phosphorescence." By Thornton J. Herapath.

"Analysis of a Mineral containing Gold, from the province of Coquimbo, Chili." By F. Field.

"Description of Lapis Lazuli, found in large quantities in the Cordilleras of the Andes." By the same.

"On the Spontaneous Decomposition of Gun-cotton and its congeners." By J. H. Gladstone, Ph. D.

"On the Action of Arsenious Acid on Albumen." By John B. Edwards.

"On the Action of Ammonia on Sebacic Ether." By T. H. Rowney.

"Analysis of the Water supplied by the Bristol Water-works Company." By Thornton J. Herapath.

"On a quick approximative method of estimating minute quantities of Iron by means of a Colorimeter." By the same.

"On the Decomposition of Citrate of Lime in contact with putrifying Curd." By Henry How.

"On a new method of obtaining Hippuric Acid in considerable quantity without evaporating the urine, and on some of its products of decomposition." By Edward Riley.

"On Populin." By M. Rafaele Piria.

"On the variation in the relative proportion of Potash and Soda present in certain samples of Barley grown in plots of ground, artificially impregnated with one or other of these alkalies." By Professor Daubeny, F.R.S.

"On the Compounds of Cotton with the Alkalies." By J. H. Gladstone, Ph. D.

"On the Occurrence of Capric and Caprylic Acids in some Fossil Oils." By T. H. Rowney.

“On Dr. Keller’s supposed formation of Metacetic Acid from Flour and Leather.” By R. W. Forster.

“On the detection of Alum in Flour, with remarks on the preparation of Distilled Water and pure Potash.” By J. H. Pepper.

“Contributions towards the history of Tannic Acid.” By Dr. Strecker.

Besides these Memoirs, formally communicated to the Society, we have had at various times laid before us interesting notices of researches now in progress in foreign countries; as, for instance, of the new process for determining urea, invented by Baron Liebig, which promises, when fully worked out, to facilitate greatly the observations which the physician and the physiologist are equally interested in making, respecting the changes that occur in this important ingredient of the urinary secretion.

And now, Gentlemen, little more remains, except for me to express my warmest thanks to the Members of the Council generally, and to the Secretaries in particular, for the kind manner in which they have relieved me from the more onerous part of my duties, by the constant attention bestowed by them on the business of the Society, rendered this year more than ever laborious by the arrangements consequent upon the change of our rooms. Without their advice and co-operation, indeed, it would have been impossible for me, living as I do at a distance from the metropolis, to have accepted the honourable post you have in so flattering a manner assigned to me, however desirous I might be to discharge its duties, so far as my time and abilities permitted. Indeed I have more reasons than one to apologize to you for my deficiencies and shortcomings, especially when I compare myself to the distinguished men who have preceded me in this office. Not only have I felt myself less able efficiently to discharge its duties, by reason of my residing so much farther from my post than any of the former presidents, but, divided as my time has long been between two complicated and rapidly advancing sciences, I am necessarily the less competent to grapple with many of those intricate questions in chemical philosophy upon which I might be expected to offer an opinion.

Perhaps, indeed, paradoxical as it may sound, the wide range of subjects which Chemistry herself embraces, or to which she is able to lend a helping hand, may be regarded as the very circumstance which has most contributed to reconcile me to undertaking other duties in conjunction with those which devolve upon me as Professor of Chemistry in the University to which I belong. The changes,

for example, brought about by nature or induced by art in the growing vegetable, cannot but be influenced by those laws, which are common to matter, whether inert or living, and thus are brought, to a certain extent at least, under the domain of Chemical Philosophy. Hence, Vegetable Physiology (and Rural Economy also, so far as that art is directed by scientific principles) appears less alien to the pursuits of a chemist than it would be to those of a man of science, who was devoted to any kind of natural philosophy more limited in its range of subjects. And, I may add, this infinite variety in the nature of the researches which our science includes within its jurisdiction, affords, in my opinion, the most convincing argument that can be offered on behalf of the necessity for the existence of a society like ours, exclusively dedicated to its promotion. Formerly, indeed, the attempt to draw off from the Philosophical Transactions any portion of that class of contributions upon which so much of their credit has ever rested, might have been viewed with some jealousy by the Royal, the common parent of all those societies which have subsequently started up.

But such a feeling cannot reasonably be entertained at the present moment, when chemistry has so enlarged its boundaries as to embrace within its compass the kingdoms of living as well as of inanimate nature. For without here pronouncing upon the difficult and much debated question as to the extent to which vital functions are influenced by chemical laws, it may be sufficient to establish the justice of my remark, if we recollect that an infinite variety of curious and important chemical products owes its origin to vital processes, in so far as the latter, by bringing together the particles of matter under conditions not imitable by art, do in fact supply us with a number of new principles to work upon, in addition to those furnished by the mineral kingdom; elements, indeed, inasmuch as they are the roots of new combinations, although themselves compounds, as being made up of bodies regarded by us as simple.

Under such circumstances, it must be apparent to every one that the Royal Society could never have taken cognizance of the whole of that vast range of subjects which modern chemistry embraces, and that many papers of great promise and of much practical utility would have been lost to the world, but for the existence of such a society as our own. Moreover, the experience of the last ten years has completely established the position, that at no period in the history of the Royal Society have more important Chemical Papers appeared in its Transactions, and at none has the number of Communications to it in the same department been so numerous as they

have been since the Chemical Society has been established. I need only allude to the memoirs of Graham, of Hofmann, and of Brodie, in proof of the former part of this assertion, namely, as to the value of the Chemical Papers which have been recently supplied to the Philosophical Transactions by members of the Chemical Society.

With respect to the second part of my statement, I may remark, that the average of papers on chemical subjects, not including electricity, contained in the Philosophical Transactions during the ten years preceding the foundation of the Chemical Society, was only about 3 in two years, or 16 in ten years; that during the first four years of our existence, namely, from 1842 to 1846 inclusive, the number of papers was 12, or $2\frac{1}{2}$ yearly; whilst, during the last quinquennial period, they have risen to 20, or to 5 on the average each year.*

Yet although there is good ground for believing that the establishment of this Society, so far from damaging the interests of the Royal, has rather tended to advance them, serving, as it has, as a feeder to that great original trunk of scientific information; and although it is true, that the spirit of the age no less than the extension of the fields of research in each department, calls imperatively for a multiplication of scientific institutions throughout the country, it affords at the same time no argument against their juxtaposition. Indeed, any arrangement which should effect this object, with respect to the chartered scientific institutions of the capital, would have much to recommend it, not only on the ground of economy and convenience, inasmuch as one set of accounts might then do the work of several societies, and one meeting-house serve the purpose, perhaps, of the whole number so brought together; but also in materially promoting the object which each of us has in

* This may be seen by the following table.

1831	2 Papers.	1842	3 Papers.
1832	0 "	1843	2 "
1833	2 "	1844	2 "
1834	2 "	1845	5 "
1835	0 "	1846	1 " 13 Papers.
1836	1 "	1847	1 "
1837	2 "	1848	4 "
1838	1 "	1849	4 "
1839	1 "	1850	9 "
1840	5 "	1851	5 " 23 "
1841	0 "		
Total . . 16		Total . . 36	

common, by facilitating the intercourse between men engaged in different departments of inquiry, and by removing some of the obstacles that impede their mutual co-operation; thus rendering the same service to the metropolis which the British Association for the Advancement of Science professes to do with reference to the provinces.

Whilst, therefore, I congratulate you, as indeed I have already done, on the additional conveniences afforded by our present suite of apartments over our last, I would still more heartily hail the day which should see all the principal chartered societies of the metropolis under a common roof, pursuing their separate labours indeed independently, but at the same time deriving mutual support and assistance from their contiguity; exercising no paramount jurisdiction, but moving forwards in harmony and concert, as becomes the federal members of the great republic of science.

The audited Statement of the Treasurer's Account was submitted to the Society as follows:

1851. March 31. 1852. March 30.	To Balance from last Account	£.	s.	d.	1852. March 30.	By payment to Mr. Abel, for Translations " Ditto to Mr. Watts, One Year's Salary, as Editor of "Journal" " Ditto to Mr. Medlock, One Year's Salary, to 31st Dec. last " Ditto ditto, for Petty Cash " Ditto to Mr. Redwood, for ditto " Ditto to H. Baillière, for Publishing Journals " Ditto ditto, for Periodicals to 30th June last " Ditto to Williams and Norgate, for Foreign Books " Ditto to John Chapman, for One Year's Rent of Apartments, 142, Strand, to Michaelmas last, £55; and for Tea and Coffee, £8 " Ditto for a Turkey Carpet for Council-room " Ditto to R. Ireland, for Book-cases and Mahogany Seats " Ditto to Thos. Ames, for Thirteen Mahogany Chairs " Ditto to Thos. Holland, for a Mahogany Glass Case " Ditto to S. Gale, for Gas-fittings, Diagram-board, &c. " Ditto to J. Crandal, for Bookbinding " Ditto to T. Treloar, for Cocoa-nut Matting " Ditto to Bunn & Co., for Floorcloth " Ditto to Mr. Rickers, for Books " Ditto to W. S. Burton, for Coffee-machine and Teaspoons " Ditto for Bottles, and expenses in removing Specimens from the Great Exhibition " Ditto to Thos. Riddle, for Chairs, &c. " Ditto to S. Kirkman, for tea, coffee, &c., including £4. 9s. for Attendance and Table, to 31st Dec. last " Ditto to Cavendish Society for Subscription, 1852 " Ditto for Envelopes and Postage-stamps for Treasurer " Ditto for Power of Attorney to receive Dividends " Ditto to John Gifford for Engraved Brass Plate " Ditto to C. Button, for 246 Stopped Bottles " Ditto to Yool & Son, for Coals and Wood " Ditto to Schulze & Co., for Printing Circulars " Ditto to Directors of Polytechnic Institution for Rent to 25th inst. " Ditto to ditto, for Tables and Furniture " Ditto to R. Taylor, for 15 Nos. of "Philosophical Magazine" " Ditto to ditto, for Printing Catalogues, &c. " Ditto to Collector, for Foundage, including 14s. for Stamps, &c. " Balance carried to his Debit in next Account	£.	s.	d.
1851. March 31. 1852. March 30.	To Balance from last Account	263	9	0	1852. March 30.	By payment to Mr. Abel, for Translations " Ditto to Mr. Watts, One Year's Salary, as Editor of "Journal" " Ditto to Mr. Medlock, One Year's Salary, to 31st Dec. last " Ditto ditto, for Petty Cash " Ditto to Mr. Redwood, for ditto " Ditto to H. Baillière, for Publishing Journals " Ditto ditto, for Periodicals to 30th June last " Ditto to Williams and Norgate, for Foreign Books " Ditto to John Chapman, for One Year's Rent of Apartments, 142, Strand, to Michaelmas last, £55; and for Tea and Coffee, £8 " Ditto for a Turkey Carpet for Council-room " Ditto to R. Ireland, for Book-cases and Mahogany Seats " Ditto to Thos. Ames, for Thirteen Mahogany Chairs " Ditto to Thos. Holland, for a Mahogany Glass Case " Ditto to S. Gale, for Gas-fittings, Diagram-board, &c. " Ditto to J. Crandal, for Bookbinding " Ditto to T. Treloar, for Cocoa-nut Matting " Ditto to Bunn & Co., for Floorcloth " Ditto to Mr. Rickers, for Books " Ditto to W. S. Burton, for Coffee-machine and Teaspoons " Ditto for Bottles, and expenses in removing Specimens from the Great Exhibition " Ditto to Thos. Riddle, for Chairs, &c. " Ditto to S. Kirkman, for tea, coffee, &c., including £4. 9s. for Attendance and Table, to 31st Dec. last " Ditto to Cavendish Society for Subscription, 1852 " Ditto for Envelopes and Postage-stamps for Treasurer " Ditto for Power of Attorney to receive Dividends " Ditto to John Gifford for Engraved Brass Plate " Ditto to C. Button, for 246 Stopped Bottles " Ditto to Yool & Son, for Coals and Wood " Ditto to Schulze & Co., for Printing Circulars " Ditto to Directors of Polytechnic Institution for Rent to 25th inst. " Ditto to ditto, for Tables and Furniture " Ditto to R. Taylor, for 15 Nos. of "Philosophical Magazine" " Ditto to ditto, for Printing Catalogues, &c. " Ditto to Collector, for Foundage, including 14s. for Stamps, &c. " Balance carried to his Debit in next Account	9	2	6
1851. March 31. 1852. March 30.	Subscriptions £221 2s. and Compositions £30, since received	251	2	0	1852. March 30.	By payment to Mr. Abel, for Translations " Ditto to Mr. Watts, One Year's Salary, as Editor of "Journal" " Ditto to Mr. Medlock, One Year's Salary, to 31st Dec. last " Ditto ditto, for Petty Cash " Ditto to Mr. Redwood, for ditto " Ditto to H. Baillière, for Publishing Journals " Ditto ditto, for Periodicals to 30th June last " Ditto to Williams and Norgate, for Foreign Books " Ditto to John Chapman, for One Year's Rent of Apartments, 142, Strand, to Michaelmas last, £55; and for Tea and Coffee, £8 " Ditto for a Turkey Carpet for Council-room " Ditto to R. Ireland, for Book-cases and Mahogany Seats " Ditto to Thos. Ames, for Thirteen Mahogany Chairs " Ditto to Thos. Holland, for a Mahogany Glass Case " Ditto to S. Gale, for Gas-fittings, Diagram-board, &c. " Ditto to J. Crandal, for Bookbinding " Ditto to T. Treloar, for Cocoa-nut Matting " Ditto to Bunn & Co., for Floorcloth " Ditto to Mr. Rickers, for Books " Ditto to W. S. Burton, for Coffee-machine and Teaspoons " Ditto for Bottles, and expenses in removing Specimens from the Great Exhibition " Ditto to Thos. Riddle, for Chairs, &c. " Ditto to S. Kirkman, for tea, coffee, &c., including £4. 9s. for Attendance and Table, to 31st Dec. last " Ditto to Cavendish Society for Subscription, 1852 " Ditto for Envelopes and Postage-stamps for Treasurer " Ditto for Power of Attorney to receive Dividends " Ditto to John Gifford for Engraved Brass Plate " Ditto to C. Button, for 246 Stopped Bottles " Ditto to Yool & Son, for Coals and Wood " Ditto to Schulze & Co., for Printing Circulars " Ditto to Directors of Polytechnic Institution for Rent to 25th inst. " Ditto to ditto, for Tables and Furniture " Ditto to R. Taylor, for 15 Nos. of "Philosophical Magazine" " Ditto to ditto, for Printing Catalogues, &c. " Ditto to Collector, for Foundage, including 14s. for Stamps, &c. " Balance carried to his Debit in next Account	50	0	0
"	Donation to Library Fund	10	0	0	"	"	25	0	0
"	Admission Fees from 22 new Members	44	2	0	"	"	8	3	0
"	Two Years' Dividends to 5th Jan. last, on £400, 3 p. c. Consols, minus Property Tax	23	6	0	"	"	1	9	0
"	Proceeds of Sale of £100, 3 p. c. Consols, minus Brokerage	98	5	0	"	"	128	13	0
"	One Year's Rent in advance, to Jan. 1853, from the Meteorological Society, for use of Rooms	20	0	0	"	"	7	11	0
"	Proceeds of Sale of "Memoirs," by Mr. Taylor	4	14	10	"	"	6	0	0
"					"	"	63	0	0
"					"	"	11	7	0
"					"	"	52	3	0
"					"	"	22	15	0
"					"	"	21	0	0
"					"	"	22	0	0
"					"	"	7	8	10
"					"	"	2	11	9
"					"	"	11	10	0
"					"	"	22	2	0
"					"	"	3	0	0
"					"	"	5	18	0
"					"	"	15	18	0
"					"	"	7	14	2
"					"	"	1	1	0
"					"	"	0	2	6
"					"	"	1	1	6
"					"	"	1	5	0
"					"	"	9	14	0
"					"	"	1	10	6
"					"	"	0	19	6
"					"	"	60	0	0
"					"	"	15	18	0
"					"	"	1	15	0
"					"	"	10	0	0
"					"	"	10	19	6
"					"	"	91	12	2
"					"	"	18	10	0
£	714	18	10	0	£	714	18	10	0

London, March 30, 1852,
R. PORRETT, Treasurer.

Examined and found correct,

(Signed) { J. DENHAM SMITH,
ALFRED WHITE, } Auditors.
JOHN THOMAS WAT, }

Mr. J. J. Griffin and Dr. Price having been appointed Scrutators, the Meeting proceeded to the Election of Council and Officers for the ensuing year; and the following gentlemen were declared to have been duly elected :

PRESIDENT.

Charles G. B. Daubeney, M.D., F.R.S., F.G.S., F.L.S.

VICE-PRESIDENTS.

William Allen Miller, M.D., F.R.S.	Robert Warington, Esq.
Lyon Playfair, C.B., Ph.D., FRS.	Colonel Philip Yorke, F.R.S.

TREASURER.

Robert Porrett, F.R.S., F.S.A.

SECRETARIES.

Benjamin Collins Brodie, F.R.S.	Theophilus Redwood, Ph.D.
---------------------------------	---------------------------

FOREIGN SECRETARY.

A. W. Hofmann, Ph.D., F.R.S.

OTHER MEMBERS OF THE COUNCIL.

Thomas Anderson, M.D., Edinburgh.	H. Bence Jones, M.D., F.R.S.
John Blyth, M.D., Cork.	J. P. Joule, F.R.S.
Dugald Campbell, Esq.	G. D. Longstaff, M.D.
Warren De la Rue, Ph.D., F.R.S.	J. Arthur Phillips, Esq.
J. H. Gladstone, Ph.D.	A. W. Williamson, Ph.D.
Thomas Graham, F.R.S.	George Wilson, M.D., F.R.S.

It was moved by Dr. Warren De la Rue, seconded by Dr. Lyon Playfair, and

Resolved,

That it is desirable to alter the By-laws of the Society, in so far as they relate to the number of Vice-Presidents; so that those Fellows of the Society who have served the office of President, shall be annually proposed for election as Vice-Presidents in addition to the Vice-Presidents elected under the present By-laws; and that such alteration be made as follows :

At page 11 of the printed Charter and By-laws of the Society, in the second paragraph, and sixth line from the top, the words "*four Vice-Presidents*" to be changed to "*four or more Vice-Presidents.*"

At page 15, in By-law VII, the last line of this By-law, being the fourteenth line from the top of the page, to be expunged, and the following words to be substituted:—" *Fellows who have filled the office of President at any time since the formation of the Society, shall be proposed by the Council for election as Vice-Presidents; and this proposition shall be renewed every year, excepting when any such are again elected to the Presidency. There shall be four other Vice-Presidents who have not filled the office of President, and every year one of these shall retire from office.*"

The thanks of the Society were voted to the President, Officers, and other Members of Council, for their services during the past year.

April 5, 1852.

COLONEL PHILIP YORKE, Vice-President, in the Chair.

The following donations were announced :

"The Pharmaceutical Journal for April:" from the Editor.

"The Literary Gazette for March 20th and 27th and April 3rd:" from the Publishers.

The following gentlemen were duly elected Fellows of the Society :

The Rev. W. Thomson, M.A., Queen's College, Oxford.

Robert Keates, Esq., 35, Carter Street, Walworth.

Samuel Gale, Esq., 17, Bloomsbury Square.

A paper was read :

"On the Detection and Qualitative Separation of Tin, Antimony, and Arsenic; and on the relation existing between these metals and others which are precipitated from their acid solutions by sulphuretted hydrogen," by Charles L. Bloxam.

April 19, 1852.

PROFESSOR DAUBENY, President, in the Chair.

The following donations were announced :

"Transactions of the Royal Scottish Society," Vol. III, Part 5 :
from the Society.

Specimens of :

Caprylic Alcohol : from Dr. Williamson.

Anhydrous Benzoic Acid : from M. Gerhardt.

The following papers were read :

1. "Researches on the Constitution of Organic Acids:" by M. Charles Gerhardt; communicated by Dr. Williamson.

2. "Note on the Preparation of Carbonate of Amyl:" by John A. Bruce.

3. "New Formation of Salicylic Acid:" by H. Gerland. (From a Letter of Dr. Kolbe to Dr. Hofmann.)

May 3, 1852.

ROBERT WARINGTON, Esq., Vice-President, in the Chair.

John William Perkins, Esq., Union Wharf, Narrow Street, Limehouse, and William Wilson, Esq., 9, Maida Hill, were duly elected Fellows of the Society.

The following papers were read :

1. "On the Preparation of Anhydrous Acetic Acid:" by M. Charles Gerhardt.

2. "Chemical Memoranda:" by Robert Warington.

3. "On the Action of Ammonia upon Binoxysulphocarbonate of Amyl:" by Matthew W. Johnson.

4. "On a New Process for the Detection of Fluorine when accompanied with Silica:" by George Wilson, M.D.

May 17, 1852.

PROFESSOR DAUBENY, President, in the Chair.

Captain James Whitmore, 63, Park Street, Grosvenor Square, was duly elected a Fellow of the Society.

A paper was read :

“On a New Test for Strychnine:” by J. H. Pepper.

The Author suggests the use of a solution of red prussiate of potash in oil of vitriol as a test for strychnine, this substance developing in the solution a violet-blue colour, when added in the dry state, or dissolved in ether. An aqueous solution cannot be used, as the presence of water alone produces a blue colour.

A verbal communication was made to the Society by Dr. Gladstone, “On the Atomic Weights of some of the Elements.”

June 7, 1852.

COLONEL PHILIP YORKE, Vice-President, in the Chair.

The following donations were announced :

“Specimens of Crystallized Lead:” from H. L. Pattison, Esq.

“Two Specimens of Essential Oil of Bitter Almonds:” from George Whipple, Esq.

“The American Journal of Science and Arts for May, 1852:” from the Editors.

“The Journal of the Franklin Institute for February, March, and April:” from the Institute.

“The Pharmaceutical Journal for June:” from the Editor.

“The Literary Gazette for May 22nd and 29th, and June 5th:” from the Publishers.

“A Pamphlet on Cotton, Flax, &c., and their Bleaching; and on the Oxides and Nitrates of Lead; and Reports on the Examination

of the Supply of Water to the Town of Preston:" from F. Crace Calvert, Esq.

A resolution of the Council was read, recommending to the Society that the names of thirteen Fellows, whose subscriptions are more than four years in arrears, be removed from the list of Fellows, in accordance with the By-laws of the Society.

The following communications were read:

1. "A note from Mr. Pepper relating to a paper read at the preceding Meeting on a New Test for Strychnine."
2. "A note on the Existence of Strontia in the Well-Waters of Bristol:" by William and Thornton J. Herapath.
3. "On the Analysis of Chrome Ores:" by F. Crace Calvert.
4. "On certain Isomeric Transformations of Fats:" by Patrick Duffy.
5. "On the Qualitative Separation of Arsenic, Tin and Antimony:" by George F. Ansell.

June 21, 1852.

PROFESSOR DAUBENY, President, in the Chair.

Alfred Snee, Esq., was admitted a Fellow.

The following donations were announced:

"Specimens of Chloride of Platosammonium, Chloride of Diplatosammonium, Chloride of Diplatosammonium and Copper, Chloride of Diplatosammonium and Lead, Bichromate of Diplatosamine, Salt of Magnus, Salt of Gros:" from G. B. Buckton, Esq.

"The Quarterly Journal of the Geological Society for May, 1852:" from the Society.

"The Nineteenth Annual Report of the Royal Cornwall Polytechnic Society:" from the Society.

"The Literary Gazette for June 12th and 19th:" from the Publishers.

The following papers were read :

1. "Observations upon a New Series of Double Chlorides containing Diplatossammonium:" by G. B. Buckton, F.L.S.
 2. "On the Action of Iodine on Phosphorus:" by B. C. Brodie, F.R.S.
 3. "On the Acid Oxalates of the Earths:" by Edward Clapton.
 4. "Researches on the Anhydrous Organic Acids:" by Charles Gerhardt.
-

NOTICES

OF

Papers contained in other Journals.

Report upon the Alleged Adulteration of Pale Ales by Strychnine.

By Professors Graham and Hofmann.

Having undertaken at the request of Mr. Allsopp an inquiry into the purity of bitter beer, with particular reference to its alleged adulteration by strychnine, we now submit the results which we have obtained upon the subject.

Strychnine or strychnia, the alleged substitute for the hop, is a fine crystallizable substance, extracted from *nux vomica*, and belonging to the class of vegetable principles termed alkaloids, of which quinine from Peruvian bark, and morphine from opium, are the most familiar examples. These substances, although susceptible of the most valuable medical application in small doses, are, generally speaking, remarkable for their energy as poisons, and for the intense bitterness of their taste; two properties which are developed in strychnine in the highest degree. Half a grain of the latter substance would poison and the bitterness of the same minute quantity is perceptible in every drop of six or eight gallons of water in which it is dissolved.

It may be stated at once, that the quantity of strychnine, which we find necessary to impart to beer the degree of bitterness possessed by pale ales, is for a gallon of beer one grain of strychnine, or double the fatal dose. The price of strychnine is about 16s. the ounce, which does not amount to so much as one penny per grain. Estimating the annual production of pale ale in Burton as 200,000 barrels, the strychnine required as a bitter would, however, amount to 16,448 ounces, and cost £13,158; while nobody believes that so much as 1,000 ounces of strychnine are manufactured over the whole world. The bitterness obtained by means of strychnine is equal in degree to that of the hop, but very different in kind and easily distinguished when the two bitters are compared. The bitter

of the hop is immediate in its action upon the palate, is accompanied by a fragrant aroma and soon passes off; whilst that of strychnine is not so instantaneous; but when the impression is once made it is more lasting, and becomes, from its persistence, like that of a metallic salt. The bitter of strychnine is, indeed, easily distinguishable from that of the hop, when deliberately tasted.

Still it would be highly desirable to be able to identify strychnine in beer, by the actual extraction of the substance, and the application to it of a chemical test of absolute certainty. Fortunately those poisons which have the most violent action upon the animal economy possess often also the best marked reactions, or their physiological and chemical properties are equally salient. Thus arsenic and hydrocyanic acid are the most easily detected of chemical substances; and strychnine proves to be not far behind them in this respect.

A quantity of strychnine, not exceeding $\frac{1}{1000}$ of a grain, is tested and recognised to be strychnine in the following manner. The powder is moistened with a single drop of undiluted sulphuric acid, and a small fragment of chromate of potash placed in the liquid. A beautiful and most intense violet tint immediately appears at the points of contact, and is speedily diffused over the whole liquid. Although most intense, the colour disappears entirely again in a few minutes. The admixture of the smallest quantity of organic matter, however, interferes with the success of the process. In order to apply the test, in operating upon a complex liquid like beer, the strychnine must first be extracted from the liquid and obtained in a pure or nearly pure condition. This difficulty, which appears at first considerable, may be readily surmounted, and the strychnine, if it really exist in beer, be separated, and its nature established in the most certain manner.

For this purpose, two ounces of ivory-black, or animal charcoal were shaken in half a gallon of beer to which $\frac{1}{2}$ grain of strychnine had been purposely added. After standing over night, the liquid was found to be nearly deprived of all bitterness; the strychnine being absorbed by the charcoal. The liquid was now passed through a paper-filter, upon which the charcoal containing the strychnine was collected and drained.

The next step was to separate the strychnine from the charcoal. This was readily effected by boiling the mixture for half an hour in eight ounces of ordinary spirits of wine, avoiding loss of alcohol by evaporation. The spirits which now contained the strychnine were next filtered, and afterwards submitted to distillation. A watery fluid remained behind, holding the strychnine in solution, but not sufficiently pure for the test. The final purification was accomplished by adding a few drops of potash to the watery fluid, and then shaking it with an ounce of ether. A portion of the ethereal solution evaporated upon a watch-glass, left a whitish solid mass of intense bitter-

ness, and this was recognised to be strychnine, by giving the violet tint previously described, upon the application to it of sulphuric acid and chromate of potash.

Having satisfied ourselves by repeated experiments with samples of beer to which strychnine had been previously added, of the never-failing efficiency of the above method of extraction, we now proceeded to the actual examination of the commercial article. With this object, a series of samples were taken indiscriminately from the stores of a considerable number of the London bottlers, who supply the public with Allsopp's pale ale.

It may be stated, that with the exception of five varieties, the casks from which these samples were taken had all been received in London before the 20th of March, *i. e.*, the period when the possible use of strychnine in the manufacture of bitter beer was first brought before the English public.

Not one of these varieties of beer, when tested with the greatest scrupulousness, gave the slightest evidence of the presence of strychnine.

The charge of adulteration of beer by strychnine has been proposed in a manner so vague, that it is difficult to fix it, and try its validity. The existence of the adulteration is not alleged in any particular sample of beer, nor the practice ascribed to any individual brewer or dealer. An English journalist adopts the charge, upon the report that such an opinion is entertained and expressed by a French chemist of distinction, M. Payen, in his public lectures at Paris. From this gentleman we have since obtained explanations which define more closely the kind of charge which was actually made by him. The late M. Pelletier, the well-known manufacturer of organic products in France, had received at one time an order for an extraordinary quantity of strychnine, of which the destination was at first unknown to him; but which he afterwards learned had been entirely exported to England, and used, as he informed M. Payen, to complete the bitter of certain kinds of beer.

We have reason to know, although it is not stated by M. Payen, that these remarks of Pelletier refer to a period ten or twelve years past; and further, although not informed of the amount of the order, we have good authority to state that fifty or a hundred ounces would have been considered a large order for strychnine at that time. The calculation already given, shows how utterly insignificant such a supply of strychnine would be for its imagined application in the pale ale breweries. It is likewise known that the manufacture of strychnine has not been on the increase in France of late years.

M. Payen excuses his statements on the ground that similar suspicions are conveyed in a French work, on "Adulterations and Falsifications," by Chevallier, published nearly a year ago, but which

have not hitherto received any formal contradiction in England. Notwithstanding the latter circumstance, our distinguished correspondent concludes by expressing his regret that he ever said "that the fraud appeared to have been practised," although he had added the remark at the time, "that this falsification had no doubt ceased."

It thus appears, that the charge which has been put into the mouth of M. Payen, was never made at all by that gentleman, so far as it applies to the present practice of English brewers, and with reference to anterior times, that the charge reposes simply and exclusively upon the privately expressed opinion of a deceased chemist, the grounds of which are entirely unknown to the world, and must ever remain so.

In conclusion, it is scarcely necessary to refer to the sifting nature of the chemical examination which the beers of Messrs. Allsopp's manufacture for many months past, have been subjected to, and which establish their incontestable purity. Indeed, no one who has witnessed, as we have done, the open manner and gigantic scale in which the operations are conducted in their establishment, could entertain the idea for a moment, that any practice involving concealment was possible. But even in the absence of all such scrutiny, the idea of strychnine being mixed with beer anywhere, or in any circumstances, involves an amount of improbability which might well dispel all suspicion on the subject.

There is an act of Henry VII., which prohibits the *adulteration* of ale by brimstone or *hops*. The place of the hop was then supplied by sage, horehound, chamomile, and other indigenous bitter plants. Since that period, the character of the national beverage must have undergone a silent revolution, for all varieties of beer, both pale and brown, now owe their distinctive properties to the hops which are boiled in the malt-infusion, and fermented along with it, as completely as wine owes its peculiar character to the grape. Substitute any other bitter for the hop, and the fermented wort would no longer be recognised as beer.

Were mere bitters all that is required, it would be easy to prove that the extract of quassia would supply a bitter which is perfectly harmless and agreeable, and infinitely less expensive than strychnine.

But the process of brewing pale ale is one in which nothing but water, the best malt and hops, of the first quality are used, and is an operation of the greatest delicacy and care, which would be entirely ruined by any tampering with the materials employed. Strychnine could not fail to be rejected, from the ungrateful, metallic character of its bitterness, independent of all objections of a more serious kind. This peculiarity of taste is also calculated to betray its presence. Small, too, as the proportion of strychnine may be, which is necessary to impart the degree of bitterness of pale ale, the quantity rises, as has been seen, to a poisonous dose in half a gallon of the fluid;

and as this poison is one of those which are known to accumulate in the system, its poisonous action would inevitably follow, in occasional cases, upon the consumption of much smaller portions of beer when continued for many days without intermission. The violent tetanic symptoms of poisoning by strychnine are also such as could scarcely fail to excite suspicion and alarm. Add to these disadvantages, the certainty of the means of detecting strychnine in beer by the chemical tests described above, which any medical man or practical chemist can apply, and the chance of the use of so dangerous a substance for any purpose of adulteration, becomes in the last degree improbable.

On the Polarizing Crystals produced by the action of Iodine on the Sulphate of Quinine.*

By Dr. Herapath.

(ABSTRACTED BY THE AUTHOR.)

In March last, Dr. Herapath announced the discovery of a beautiful crystalline compound, possessing the optical properties of the tourmaline, and even in a superior degree to this mineral. It also, at certain angles of rotation, would act as selenite, viz., depolarize a ray.

This remarkable body was procured in the following way :

About 10 grains of di-sulphate of quinine were dissolved in half a fluid ounce of pure acetic acid, and gently warmed; a spirituous solution of iodine was then cautiously added, a few drops at a time; the whole again gently heated to dissolve the cinnamon-brown precipitate first produced, and the mixture set aside for several hours to crystallize.

When these crystals were examined by reflected light, they were found to possess a brilliant emerald-green colour, similar to murexide, or the fragments of the elytra of cantharides; but by transmitted light, they were almost colourless and transparent, having a slightly olive-green tint only.

The forms of these crystals are very various: prismatic plates, parallelipeds, rhomboidal parallelograms, and hexagonal plates very perfect; but by very careful manipulation and slow crystallization, the author obtained large compound plates composed of many flat prisms, joined edge to edge, and all in the same plane; by which means he was enabled to produce crystals large enough to furnish his microscope with artificial tourmalines, and to perform all the experiments usually exhibited by the polarizing microscope.

* Phil. Mag. and Pharm. J. [4], III, 161.

Upon submitting this substance to chemical analysis, he discovered the fact of its being a compound of iodine, sulphuric acid, and quinine; many experiments prove that all these constituents are absolutely essential to its production, and the removal of either will destroy the compound.

At first Dr. Herapath proposed the name of *iodide of disulphate of quinine*; but a recent quantitative analysis has occasioned a change in the idea of its constitution, and he now proposes that of *sulphate of iodo-quinine*.

Similar experiments were made with other vegetable substances, especially alkaloids, viz., quinidine (β -quinine), cinchonine, brucine, strychnine, morphine, and salicine, but without success.

The chemical characters of this salt are the following:

The crystals are immediately dissolved, upon heating the mother-liquid to 180° F. ($82\frac{2}{3}$ C.), but recrystallize on cooling. They are dissolved by diluted sulphuric acid, upon exposure to air on a plate of glass. Distilled water also has a disintegrating action on them. Alcohol, boiling, dissolves them readily. They partially fall again, on cooling, but altered in form. They are now rosettes, composed of small hexagonal plates. Ether and chloroform have no action on them. Ammonia destroys them directly. They become opaque, and orange-yellow, the iodine and sulphuric acid being both partially removed, quinine and iodine remaining combined.

The primary form of this crystalline substance appears to be the rhombic prism.

The optical properties present many most interesting peculiarities, and to observe them, a power of 100 diameters is necessary.

1. When two crystals are crossed at right angles, the space where they are superimposed is as dark as midnight, or slightly brown, according to the thickening of the plates. (Figs. 1, 2, 3, 4 and 6.)

FIG. 1.

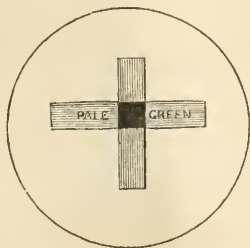
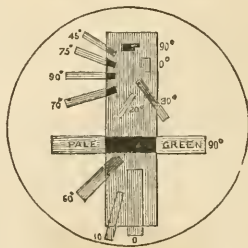


FIG. 2.



2. When two prisms are superposed, but perfectly parallel in their long diameters, the light passes through unaltered. (Figs. 2 and 3.)

3. When they cross at 45° , polarization occurs, but not so intensely as at 90° . (Figs. 2 and 4.)

4. There is a perceptible polarizing effect at 30° , but below this angle there does not appear to be any effect on transmitted light. (Fig. 2.)

5. When three crystals are examined in a superposed position : two of these being at right angles, and therefore at the maximum of polarization, the third placed between these at 45° —the phenomenon of depolarization is produced. The interposed crystal permits the light to pass through, and at the same time communicates to it the order of colour equivalent to its thickness, in the same manner as a plate of selenite would do, if introduced between two tourmalines at right angles to each other. (Fig. 4.)

FIG. 3

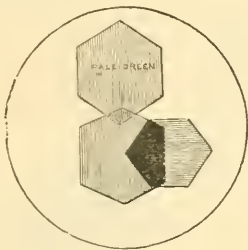
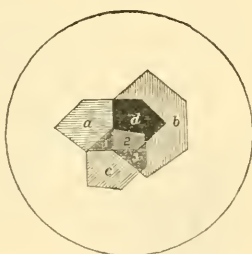


FIG. 4.



6. Upon examining two of these prisms with a single tourmaline, that one parallel to the plane of the analyser allows the light to pass through. But the crystal which is at right angles to the plane of the tourmaline is wholly dark ; it stops the ray perfectly. (Fig. 5.)

7. Three crystals arranged in the following way are examined by a single tourmaline above the eye-piece. Let the inferior crystal be at right angles to the tourmaline, the two superior crystals crossing each other at 90° , but each intersecting the inferior at 45° ; polarization takes place between the inferior crystal and the tourmaline ; but the two intermediate crystals depolarize, where they intersect the inferior crystal ; polarize where they cross each other at 90° . (Fig. 6.)

FIG. 5.

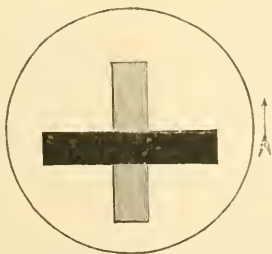
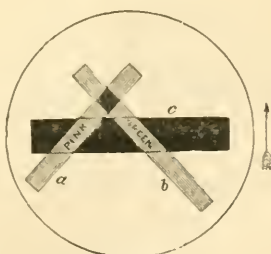


FIG. 6.



8. Upon examining two of these crystals, crossing each other at

90° in the polarizing microscope, the two tourmalines being crossed at 90° , of course the field will be dark; and if the crystals coincide with the planes, they will not be visible, at least the only evidence of their existence in the field will be a greater intensity in the darkness; but upon revolving the crystals through an arc of 45° , they directly depolarize the light, and of course permit it to pass through the superior tourmaline.

9. The most remarkable effect is discovered in examining this object by means of a single and inferior tourmaline, with a selenite stage placed upon it (this arrangement occupies the stage of the microscope); on placing the new crystals in the field, we observe that all those which are parallel to the plane of the tourmaline are brilliant green, all those at right angles are vivid red or wine-colour—supposing the stage to be the red selenite. Revolve the object through 45° , and they become both slightly olive-green.

FIG. 7.

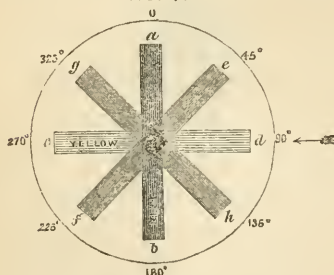
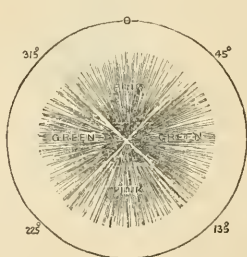


FIG. 8.



10. Upon replacing the red selenite by a film exhibiting the blue tint, then that crystal which is at right angles to the polarizing plate of tourmaline, develops the blue colour of the stage, whilst that which is parallel to the tourmaline, exhibits the complementary yellow (Fig. 7). Upon revolving the object 45° , the two crystals become nearly of a neutral-tint. If these crystals are superposed in these experiments, the space where they cross is necessarily dark.

11. The same phenomena are exhibited by the hexagon, and all other forms of the crystals.

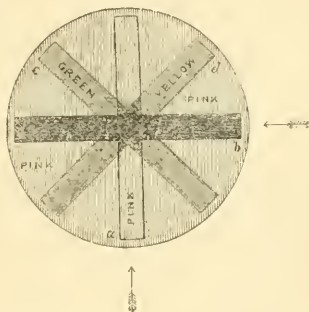
12. The single tourmaline and the selenite stage are thus exceedingly delicate tests of the power which substances possess of *polarizing* light; the author has, by its means, discovered that many substances possess the power, as disulphate of quinidine (β -quinine) (Fig. 8); this is much more intense in its power than the disulphate of quinine, and has been used as a means of discriminating them.

13. The next experiment to which the new crystals were submitted was the usual arrangement of the polarizing microscope, viz.: *two*

tourmalines at 90° , and the selenite stage (pink)—of course the whole field of the microscope is pink or wine coloured.

Upon introducing the object, all those crystals which are at right angles to the analyzing or superior plate of tourmaline, are intensely dark brown, or black, according to their thickness. All those which are parallel to the same tourmaline allow the pink colour of the stage to pass through them; whilst those which are from 45° to 225° , and from the points 315° to 135° , are green or yellowish; they are in the plane of depolarization, and add their crystalline thickness to the selenite stage. (Fig. 9.)

FIG. 9.



14. Upon replacing the pink stage with a blue plate, the whole field will, of course, be intensely blue; introduce the object, the crystals at right angles to the upper tourmaline will polarize, and produce a dark brown or black as before. Those parallel to it will allow the blue colour to pass through them.

The two crystals (45° to 225°) and (315 to 135°) will be violet and orange-yellow respectively, being complementary in colour to each other.

15. Upon revolving the superior tourmaline in the two last experiments, the whole appearance changes; the field becomes in one case green, and yellow in the second instance, and the crystals change colours also; but the principles involved are the same in both experiments.

16. Not only do these crystals polarize light by *transmission*, but when used as reflecting surfaces, they also alter the ray and reflect a beam polarized in one plane when the light is incident upon them at an angle of 41° .

17. It has been already stated, that the author has succeeded in adapting one of these artificial polarizing crystals to the stage of his microscope; it is sufficiently large to give an uniform tint to the whole field, and covers a surface $\frac{1}{8}$ th of an inch in diameter. This will bear magnifying to any extent; and he has been enabled to illuminate

a field of 11 inches in diameter with light polarized by its means. Since this period, Dr. Herapath has succeeded in making one large enough to surmount the eye-piece of his instrument, so that he is now perfectly independent of the tourmaline and Nichol's prism in all his experiments on polarized light; his artificial crystals possess some advantages over the natural tourmalines, in giving much more brilliant colours than when two tourmalines are employed; and as an ocular analyser, it is superior to the Nichol's prism, as it gives a larger field when properly mounted.

18. When the sulphate of quinine happens to crystallize in radiating prisms beneath the large compound plates, as it will readily do if there be an excess in the mother liquid, a splendid object is obtained, not to be equalled by any known combination. Upon placing a selenite stage beneath this object, the plate becomes coloured according to the thickness of the stage, and the angle of the crystal's rotation, whilst the sulphate of quinine exhibits all the splendour of the rainbow. The analysing plate of tourmaline is not employed above the eye-piece.

19. Upon submitting these artificial plates to micrometrical measurement, it was found that those which possessed sufficient thickness to adhere together in clusters, and to raise themselves upon their edges so as to exhibit their thickness, were none of them more than $\frac{1}{300}$ th of an inch, many of them $\frac{1}{600}$ th or $\frac{1}{900}$ th of an inch only; but even these were much thicker than any of the broad, thin plates, so readily broken, some of which were successfully mounted; these could not have been more than $\frac{1}{1000}$ th of an inch; and when it is recollected, that tourmalines, as sold for optical purposes, are generally from $\frac{1}{100}$ th to $\frac{1}{50}$ th of an inch, it is at once apparent that this newly-discovered salt of the vegetable alkaloid quinine, is the most powerful substance known as a polarizing crystal.

QUANTITATIVE ANALYSIS.

Having previously satisfied himself that iodine, sulphuric acid and quinine entered into the composition of the crystals, the author undertook the quantitative analysis; but before attempting this, it was of course necessary to invent a process which would furnish a large quantity of this substance at one operation. After several attempts, with more or less success, the following method was adopted, which, at the same time, served as a means of corroborating the results of the future analysis, as it enabled the experimenter to account for all the iodine used in the operation.

A tubulated retort was adapted to a receiver by careful connections, and the latter adjusted to a second receiver, somewhat in the manner of a Wolff's apparatus; the condensers were then surrounded

by a freezing mixture of nitrate of potash and chloride of ammonium.

Into the retort were placed 100 grains of pure disulphate of quinine, with three fluid ounces of acetic acid; two drachms of diluted sulphuric acid (containing about twelve grains of dry acid). When this mixture had been raised to 110° Fahr. ($43\frac{1}{3}^{\circ}$ C.), the alcoholic solution of iodine was gradually added through a bent glass funnel adapted to the tubule of the retort. In this manner thirty grains of iodine, dissolved in 1150 grains of alcohol were employed. The whole operation occupied about half an hour, during which period a reddish-brown coloured fluid distilled and collected in the receivers—about four fluid drachms in quantity. This of course was carefully set aside for examination. The whole was allowed to become cold, still in connection; an abundant crop of crystals formed in the retort, which, having been kept during twenty-four hours at a temperature of 40° Fahr. ($4\frac{4}{9}^{\circ}$ C.) to deposit, were collected on a filter, and washed several times with acetic acid at 40° Fahr., which had been previously found to have little solvent power on this compound at that temperature. The crystals having been well washed, were dissolved in boiling alcohol, sp. gr. 0.838, and, on cooling, they recrystallized; this operation being repeated, they were at length obtained pure from any admixture of disulphate of quinine. Having been drained on a filter and washed with cold spirit, they were dried at 90° Fahr., ($32\frac{2}{9}^{\circ}$ C.) and subsequently over sulphuric acid and weighed. By this operation 66.6 grains were obtained.

The acid mother-liquid, together with the first washings, was then examined for iodine. Upon allowing a few drops to evaporate spontaneously on a slip of glass, polarizing crystals formed around the edge of the liquid; consequently the compound is slightly soluble in cold acetic acid and spirit. The acetic acid having been nearly neutralized by ammonia, nitrate of silver was dropped into the solution as long as any iodide of silver was deposited. This was then carefully collected on a filter; washed repeatedly with distilled water; then with ammonia to remove any chloride; again with distilled water; then dried, ignited, and weighed; it gave 2.00 grains=iodine 1.08 grains.

The alcoholic mother-liquids and washings were then examined for iodine; crystals were similarly obtained upon spontaneous evaporation. In order to precipitate the iodine, a solution of silver was used, and dropped into the fluid as long as any cloudiness was produced; the whole thrown on a filter; and the precipitated iodide of silver washed with diluted nitric acid to remove any quinine, subsequently with ammonia to take up any chloride, and then again with distilled water. Dried, ignited, and weighed, it gave 3.63 grains=1.951 grains of iodine.

It now remained to examine the distilled liquids for iodine; as it

existed in these in the free state, dissolved in alcohol, they were mixed together and a little water added, and placed in a counterpoised flask with metallic zinc. After prolonged digestion, the iodine was converted into iodide of zinc; the fluids were then distilled off and the iodide of zinc dried at 100° C. and weighed; it gave 3.35 grains = 2.6715 grains of iodine.

Now if any substitution-compound had been formed by the action of the iodine on the quinine, it was probable that hydriodic ether would have been produced; if so, it would be found in the distilled fluid. This was carefully examined for this substance, but none detected; subsequent experiments showed that none could have been produced, or if any, so small in quantity that its presence would be immaterial; for all the iodine used, with the exception of 2.56 grains, can be accounted for thus:

21.7375 grains iodine in the 66.6 grains of crystals. (Calculated at 32.63 per cent., as found subsequently.)		
1.0800	„	iodine in the acetic mother-liquid (crystals).
1.9510	„	iodine in the alcoholic mother-liquid (ditto).
2.6715	„	iodine in the distilled fluid as free.

27.4400

2.56 grains iodine lost. This was lost in drying the crystals by expression between folds of bibulous paper.

Had a substitution-compound been formed, one-half of the iodine should have formed hydriodic acid; the other half should have been in the crystalline compound, as the substitution-base; therefore, it is evident that no such substitution-base can be the result.

One other question arises—Does the iodine exist in the green crystals as hydriodic acid?

Some of the crystals were dissolved in *diluted* alcohol (boiling) and starch added to the liquid still warm; instantly an abundant precipitation of the blue iodide of amidine occurred; starch was added in excess, and until no further indications of iodine were evident; the colourless fluid was then separated by decantation, and tested with nitrate of silver: not the least trace of hydriodic acid, or any soluble iodide was apparent. Similar results were obtained when the crystals were dissolved in hot acetic acid and tested with starch. It is evident, therefore, that no hydriodic acid is present in the crystals; and consequently, that the iodine cannot exist in the compound as a substitution-base, or even as hydriodic acid.

The iodine separating so readily in the free state, upon dissolving the crystals in alcohol, or in acetic acid, rendered it a somewhat difficult matter to estimate it correctly: starch was first used as the precipitant: the resulting iodide of amidine decomposed by sulphuretted hydrogen, the hydriodic acid produced, neutralized by

ammonia, this precipitated by nitrate of silver, and the resultant iodide of silver estimated; but accuracy was far from being obtained by this method, in consequence of iodine subliming during the solution of the crystals.

(a) At length it was found that by passing a current of washed and pure sulphuretted hydrogen through acetic acid, in which a known quantity of crystals had been placed, and applying heat to the mixture as soon as the gas began to be evolved, the iodine was converted into hydriodic acid as soon as it was liberated from the crystals. The decomposition being perfect, and the operation finished, the excess of sulphuretted hydrogen was expelled by boiling, testing with acetate-of-lead-paper from time to time during this part of the process; the precipitated sulphur removed by filtering, and well washed with distilled water; ammonia added to the filtrate nearly to neutralization, but short of precipitating the quinine; the solution boiled, and the iodine precipitated by nitrate of silver; the precipitate collected on a filter, washed with distilled water, then with diluted nitric acid (to remove any quinine which falls with iodide of silver even from an acid solution), and lastly, dried and fused by ignition in a platinum capsule. Twenty-five grains of crystals gave by this method 15.14 grains of iodide of silver = 8.1523 grains of iodine = 32.6092 per cent.

(β) The solution, after the separation of iodine, was then, together with the washings, treated with acetate of baryta, until no further deposition of sulphate occurred; it was boiled to hasten the separation, filtered, washed, dried, and ignited; it weighed 7.76 grains = 2.653 SO_3 = 10.612 per cent of sulphuric acid.

(γ) The liquid, after the separation of iodine and the sulphuric acid, was then acted on, first by sulphate of ammonia to remove excess of baryta, then with hydrochlorate of ammonia to remove the excess of silver.

(δ). To this fluid, concentrated by evaporation to about three fluid ounces, ammonia was added in excess; an immediate deposition of the alkaloid was the consequence. Ether was now added in sufficient quantity to dissolve the alkaloid; the supernatant ethereal fluid was decanted into a counterpoised flask, the operation being repeated as often as necessary; the mixed ethereal fluids distilled; and the residuary alkaloid dried at 100°C .: it gave 7.533 grains.

(ε). The aqueous and ammoniacal solution, upon evaporation to dryness in a water-bath, and again treating the residue with ether as long as necessary, and distilling as before, furnished a second quantity of the alkaloid, which, dried at 100°C . as before, weighed 3.14 grains.

Then $7.533 + 3.14 = 10.673$ alkaloid equal to 42.692 per cent.

This analysis, therefore, accounts for—

Iodine	32·6092
Sulphuric acid	10·6120
Alkaloid	42·6920
	85·9132

The loss 14·0868, was possibly water of crystallization; but it now became necessary to perform an analysis to make this point certain. After several attempts, the following process was adopted, and furnished correct results.

Having arranged an apparatus for preparing a current of dry hydrogen gas, the stream was passed through a flask containing iron filings. These were then heated red-hot; the oxide of iron was reduced to the metallic state. When the gas issuing from the exit-tube of the apparatus burnt with a steady yellow flame, the operation was discontinued—at least the spirit-lamp was removed—and the iron allowed to cool, still in an atmosphere of dry hydrogen gas, and when cold, removed and well secured in a small stoppered bottle.

To the same apparatus for generating the dry hydrogen, was adapted a counterpoised test-tube (*a*), and to the exit-pipe from this was connected a tube (*b*) containing chloride of calcium, this tube with its contents being also accurately counterpoised.

Into the tube (*a*) was placed a mixture of 10·2 grs. of the crystals (previously dried at 100° C.) rubbed up in a mortar with 50 grains of the purified iron-filings; the mortar was wiped out carefully with twenty grains of the same iron, and this also inserted into the tube carefully; a layer of pure iron-filings was placed over the whole, and the tube with its contents and fittings accurately counterpoised.

This part of the apparatus was then placed in a flask containing a solution of chloride of zinc, destined to act as a bath. The whole apparatus having been satisfactorily adjusted, heat was now applied to the bath, and gradually raised until the chloride of zinc ceased to give off any water, and of course fused. This must have been about 420° Fah. (215° C.), or more.

In this operation, the crystals were decomposed; the iron seized the iodine as fast as it was liberated; the quinine retained the sulphuric acid; and the current of dry hydrogen gas carried off the aqueous vapour to the chloride of calcium tube, where it was retained. The increase in weight was 1·44 grains; thus, as $10·2 : 1·44 = 100 : 14·1764$ grains of water per cent.

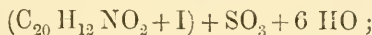
This method was also adopted as a means of estimating the iodine; but for this purpose, the chloride of zinc bath was not employed, as a more perfect decomposition was then necessary. The mass in the test-tube (*a*) was lixiviated repeatedly, as long as any iodide of iron dissolved; this was at once filtered into a solution of nitrate of

silver, iron filings being kept in the filter to avoid decomposition. The filter was repeatedly washed with boiling distilled water, and of course the washings were added to the previous liquid. The resulting mixture of iodide of silver and the oxides of iron was thrown on a filter, and washed with hot diluted hydrochloric acid as long as any iron was removed; then with ammonia to remove any chloride; and afterwards again with distilled water; and lastly dried, ignited, and weighed: it gave 6.00 grains = iodine 3.1453 and 31.453 gr. per cent, a result corresponding very closely with that previously obtained.

A second analysis specially directed to the estimation of the sulphuric acid, gave 10.844 per cent as the result. Therefore we now have:

	(α)	(β)		Calculated.
Iodine . . .	32.6092	31.453	124	32.6300 . . 1 at.
Sulphuric acid .	10.6120	10.844	40	10.5200 . . 1 at.
Alkaloid . . .	42.6920	—	162	42.6300 . . 1 at.
Water . . .	14.1764	—	54	14.2152 . . 6 at.
	100.0896		380	99.9952

These results correspond closely with the formula



and as it has been previously proved that the base is not a substitution-compound, it only remains to consider it a salt in which iodine is super-added to the base quinine without interfering with its basic properties, however much it might alter its chemical characters.

Experiments have been instituted to produce this iodo-quinine in an isolated state, but hitherto without success; the nearest approach hitherto made, is by the action of ammonia at 60° Fah. ($15\frac{5}{9}$ ° C.), by carefully triturating the polarizing crystals in the strongest liquor ammoniæ during half an hour; separating on a filter; washing with cold distilled water; and carefully drying the reddish-yellow mass produced. This contained *nearly* all the iodine and quinine; but the ammoniacal solution contained sulphate of ammonia, with some of the resinous compound dissolved in it, together with about 11.0 per cent of hydriodate of ammonia. The action of iodine on the acetate of quinine has also been tried, and the iodo-quinine has been produced; but it does not act as a base should do, namely, dissolve in acids at once without decomposition.

The resinous mass was treated with diluted sulphuric acid, in order to reproduce the polarizing crystals; they certainly were formed, but not in a satisfactory manner; some other compounds were also produced, the formation of which cannot be accounted for in the present state of the question. The alkaloid separated by the pre-

viously detailed analysis was examined; from it was first made the disulphate; this differed materially from disulphate of quinine, both in its crystalline form and its solubility. It would dissolve in about three times its weight of water, at 100° C., crystallizing in radiating plumose tufts, very similar to acetate of morphine in appearance. From this disulphate were reproduced the polarizing crystals very readily upon submitting it to the same operation as was originally used, namely, solution in acetic acid, and adding a spirituous solution of iodine to the heated fluid; on cooling, the green crystals were deposited, having their original extraordinary properties. The disulphate of the alkaloid differed as much in its optical as in its chemical characters from quinine; assimilating itself in the former to the disulphate of quinidine (β -quinine); whereas the pure alkaloid much more resembled quinine in its chemical characters, as it is soluble both in alcohol and ether, but crystallizes from neither with facility. Some slight appearance of crystallization is obtained by exposing an alcoholic solution to spontaneous evaporation in a test-tube; around the edge of the liquid, a thin radiating plumose crop is produced, more distinctly acicular than the disulphate. It is, therefore, not quinidine (β -quinine), but is probably similar to that variety of quinine recently called γ -quinine by J. Van Heijningen,* a monohydrate of the organic compound $C_{20}H_{12}NO_2$, of which α -quinine is the tri-hydrate, and β -quinine or quinidine the bi-hydrate.

However, further researches are necessary to establish this point; for the present we are justified, from the reproduction of the polarizing crystals from the alkaloid separated from the green polarizing compound by analysis, in considering that the alkaloid quinine enters into the composition of the crystals,—in the character of an iodo-base,—*not* a substitution-base, as has been already shown, but a compound analogous in its constitution to iodo-codeine, dieyano-codeine, cyaniline, cyano-toluidine, and cyano-eumidine, all of which are compounds not belonging to the series of substitution-products. This, if correct, is a remarkable circumstance, and worthy of verification by a more elaborate investigation.

* Pharm. J. January, 1850.

**On a Method of obtaining a perfect Vacuum in the Receiver of an
Air-pump.**

By Thomas Andrews, M.D., F.R.S., M.R.I.A.*

The space left vacant in the upper part of a long glass tube, which, after being filled with mercury, is inverted in a basin of the same metal, affords the nearest approach to a perfect vacuum which has hitherto been obtained. It is true that it contains a little mercurial vapour at the ordinary temperature of our summers, and probably also at lower temperatures; but the quantity is exceedingly small, and its influence in depressing the barometric column must be altogether inappreciable. Besides the mercurial vapour, a trace of air may generally be detected, even in tubes which have been carefully filled, and in which the air interposed between the glass and mercury has been expelled by ebullition. This is best observed by inclining the tube till the mercury comes into contact with the upper end, when any air that may have been diffused through the vacuum will be seen collected in a small bubble, but greatly rarefied. It is easy to calculate approximately the depression of the mercurial column produced by this residual air. For this purpose, the tube must be inclined till the bubble is exposed to a pressure of a few inches of mercury, measured in a vertical direction. In this position its apparent diameter is measured, as also the pressure to which it is exposed. For the object in view, the volume of the bubble may be calculated on the assumption that it is a sphere. The space occupied by the vacuum must also be estimated; and with these data, the depression of the mercurial column may easily be calculated.

Let V be the volume of the space above the mercury when the tube is vertical;

p , the pressure under which the diameter of the bubble of air has been measured;

r , the semidiameter of the bubble;

x , the depression of the mercurial column.

Then

$$x = \frac{4}{3} r^3 \cdot \pi p \frac{1}{V}.$$

If the diameter of the bubble, $2r$, be 0.02 inch, the pressure p , 2 inches, and the space V , 1.2 cubic inch, the value of x is nearly

* Phil. Mag. [4], III, 104.

0.00001 inch ; or the depression of the mercury, in consequence of the vacuum not being absolutely perfect, amounts only to $\frac{1}{100,000}$ of an inch. It is easy in actual practice to realize this close approximation to a perfect vacuum. The quantities now stated apply, in fact, to a barometric tube employed in an experiment which will be subsequently described.

The Torricellian vacuum leaves therefore scarcely anything to be desired in point of completeness ; but it is unfortunately applicable to very few physical investigations. No instrument of any kind can be introduced into it, nor even any substance which is acted on by mercury. The vacuum obtained by the exhausting pump is not liable to these objections ; but even with machines of the most perfect construction, and in the best order, only a very imperfect approach can be attained to a complete exhaustion. A good ordinary pump with silk valves seldom produces an exhaustion of 0.2 inch ; and it is very rare indeed, if the manometer is properly constructed, to have it carried to 0.1 inch. In his "*Etudes Hygrométriques*,"* M. Regnault has given the following method for pushing the exhaustion further after the valves have ceased to act. In a large glass globe of from 20 to 25 litres capacity ($4\frac{1}{2}$ to $5\frac{1}{2}$ English gallons), he places an hermetically sealed capsule of glass containing from 40 to 50 grms. of sulphuric acid. He also introduces into the globe 2 or 3 grms. of water, and exhausts till the water has entirely disappeared and the machine ceases to act. By agitating the globe, the capsule is ruptured ; and the sulphuric acid coming into contact with the vapour of water, which has displaced nearly all the residual air in the receiver, condenses it and leaves a vacuum nearly perfect. This globe thus exhausted is next placed in communication with the apparatus in which a very perfect vacuum is desired, taking care to remove the air from the interior of the connecting tubes. On opening the stop-cocks, the air becomes uniformly diffused through the two spaces ; and if the capacity of the globe is considerable, compared with that of the other vessel, the elastic force of the air may be reduced to a small fraction of a millimetre. If, on the contrary, the capacity of the latter is considerable, this operation must be repeated several times.

This ingenious process is not adapted to give a very perfect vacuum in the second vessel, unless the operation be repeated several times, which would be exceedingly laborious. It is also liable to other difficulties in the execution, which will at once occur to any one accustomed to experiments of this kind. Besides, it does not afford the means of obtaining a vacuum, which, as far as the indications of a mercurial manometer can be observed, is perfect ; as in M. Regnault's observations, the elastic force of the air was still capable of

* *Ann. Ch. Phys.* [3], XV, 190.

measurement, although only amounting to a small fraction of a millimetre.

By using the necessary precautions, a vacuum may be obtained by the following process, with very little trouble, in the ordinary receiver of an air-pump, so perfect that the residual air exerts no appreciable elastic force. Even after this limit has been reached, the exhaustion may be pushed still further, till it must become at last not less complete than the Torricellian vacuum; while at the same time, by suppressing the manometer, the existence of mercurial vapour may be altogether prevented. The manipulations required to arrive at this result will not interfere with the presence of the most delicate instruments in the receiver.

Into the receiver of an ordinary air-pump, which is not required to exhaust further than to 0·3 inch, or even 0·5 inch, but which must retain the exhaustion perfectly for any length of time, two open vessels are introduced, one of which may be conveniently placed above the other; the lower vessel containing concentrated sulphuric acid, the upper a thin layer of a solution of caustic potash, which has been recently concentrated by ebullition. The precise quantities of these liquids is not a matter of importance, provided they are so adjusted that the acid is capable of desiccating completely the potash solution without becoming itself notably diminished in strength, but at the same time does not expose so large a surface, as to convert the potash into a dry mass in less than five or six hours at the least. The pump is in the first place worked, till the air in the receiver has an elastic force of 0·3 or 0·4 inch, and the stop-cock below the plate is then closed. A communication is now established between the tube for admitting air below the valves and a gas-holder containing carbonic acid, which has been carefully prepared so as to exclude the presence of atmospheric air. After all the air has been completely removed from the connecting tubes by alternately exhausting and admitting carbonic acid, the stop-cock below the plate is opened and the carbonic acid allowed to pass into the receiver. The exhaustion is again quickly performed to about the extent of half an inch or less. If a very perfect vacuum is desired, this operation may be again repeated; and if extreme accuracy is required, it may be performed a third time. It is not likely that anything would be gained by carrying the process further. On leaving the apparatus to itself, the carbonic acid which has displaced the residual air is absorbed by the alkaline solution, and the aqueous vapour is afterwards removed by the sulphuric acid. The vacuum thus obtained is so perfect, that even after two operations it exercises no appreciable tension.

To give a clear conception of the progress of the absorption, I will describe in detail one observation in which the tension was measured simultaneously by a good syphon-gauge and by a manometer, formed

of a barometric tube 0·5 inch in diameter, inverted in the same reservoir of mercury as a similar tube communicating with the interior of the receiver. The barometer had been carefully filled, and the depression of the mercury estimated by the method already described at less than $\frac{1}{100,000}$ of an inch.

Previous to the admission of the carbonic acid, the exhaustion was carried only to 0·4 inch; it was again carried to 1 inch; and a third time to 0·5 inch, after which the apparatus was left to itself. The manometer indicated a pressure in—

15'	of 0·25 inch.
30'	„ 0·17 „
80'	„ 0·10 „
200'	„ 0·02 „

In twelve hours the difference of level was just perceptible, when a perfectly level surface was brought down behind the tubes till the light was just excluded. In thirty-six hours not the slightest difference of level could be detected. The vacuum has remained without the slightest change for fourteen days.

It is evident that the only limit to the completeness of the vacuum obtained by this process, arises from the difficulty of preparing carbonic acid gas perfectly free from air. This may be very nearly overcome by adopting precautions which are well known to practical chemists. When an extreme exhaustion is required, the gas-holder should be filled with recently boiled water, and the first portions of carbonic acid that are collected in it should be allowed to escape.

The substitution of phosphoric for sulphuric acid would remove the possibility of either aqueous or acid vapours being present even in the smallest amount, but such a refinement will rarely be found necessary.

In the experiment just described, the theoretical residue of air would be $\frac{1}{135,000}$ part of the entire quantity in the receiver, which would cause a depression of $\frac{1}{4,500}$ of an inch. This result must have been nearly realized. If the exhaustion had been carried at each time to 0·2 inch, the residue by theory would have been only $\frac{1}{3,375,000}$ part. But the experimental results will not continue to keep pace with such small magnitudes.

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

XVI.—*Note on the existence of Strontia in the Well-Waters of Bristol.*

BY MESSRS. WILLIAM HERAPATH AND THORNTON
J. HERAPATH.

Our attention was first directed to this subject, in consequence of the discovery of a small quantity of sulphate of strontia in the deposit or crust which had formed in the interior of a pipe in connection with the hot baths at our Royal Infirmary. We subsequently found, that this compound was also contained in very minute proportion in the water with which this institution was supplied. Having been much occupied lately in examining the well-waters from different parts of the city and its suburbs, we have succeeded in assuring ourselves that the above is not an isolated case, and that sulphate of strontia occurs to a greater or smaller extent in the waters from most parts of the city, particularly in those from the neighbourhood of Cotham, Kingsdown and West Clifton, as well as on the opposite side of the city, at Pyle Hill. The liassic and marly strata which occur here, as is well known, contain fine beds of crystallized celestine, for which this district has been long celebrated. Hence, the presence of this mineral ingredient in the water is easily accounted for.

Those waters we have found to contain the largest proportion of strontia are obtained from Cotham, on the edge of the lias, and at its junction with the new red sandstone. In one specimen which we examined from this locality, we detected as much as three-tenths of a grain of the sulphate per gallon. The process of analysis pursued

in this inquiry was as follows:—The water having been evaporated to dryness, the residuary mass was heated with an excess of pure sulphuric acid, in order to convert the whole of the earthy and alkaline salts present into sulphates, and also to get rid of the organic matter. The excess of sulphuric acid was then expelled by a further application of heat, and the fixed residue extracted, first with boiling water, and subsequently with hot hydrochloric acid, until the whole of the matters that were soluble in those menstrua were dissolved out. That which remained consisted of a mixture of silica with sulphate of strontia. In order to separate these two substances, they were placed in a platinum capsule, and exposed to the vapours of hydrofluoric acid, by which means the silica was abstracted, and sulphate of strontia left behind in the pure state. The necessity for the first operation originated from the fact that the sulphate of strontia is somewhat soluble in chloride of sodium, and therefore upon attempting to estimate it, without taking the precaution to first convert the whole of the bases into sulphates, a loss would be sustained, in consequence of the solution of a part of the sulphate of strontia in the water.

We have also discovered extremely minute traces of sulphate of strontia or sulphate of baryta in many well-waters from other localities. At all events, the siliceous residue obtained by the above process, when fused with a mixture of starch and carbonate of soda, yielded a fused mass which, upon solution in water, and testing with the nitroprusside of potassium, produced a faint violet colouration, which could only be caused by the presence of a trace of alkaline sulphide, resulting from the decomposition of an earthy sulphate insoluble in hydrochloric acid.

XVII.—*A new method for the analysis of Chrome Ores.*

BY F. C. CALVERT.

It is well known to all chemists who have analysed chrome ores, what difficulties they present, and what long and tedious manipulations are required to produce satisfactory results. In the numerous analyses of chrome ores which I have made, I have found it impossible to make two analyses of the same ore satisfactorily correspond. I have, therefore, been led to make a series of experiments, the results of which I have now the honour of laying before the Society. By the results I have obtained, I believe I have removed

the objections inherent in the present mode of attacking the ore, the first of which consists in the difficulty of obtaining crucibles capable of resisting for several hours, at a high temperature, the combined actions of nitrate and carbonate of potash, but more especially of caustic potash, which it is essential to the operator to employ in order to properly attack his ore. Silver crucibles cannot stand the temperature, and those of porcelain or platinum are either dissolved or injured.

The second and most serious objection to be raised is, that owing to the high specific gravity of the ore, it falls to the bottom of the fused mass, and thus becomes excluded from the necessary oxidizing action of the atmosphere to transform the oxide of chromium into chromic acid. As the chromic acid is thus produced but very slowly, the consequence is, the ore is very imperfectly attacked, although the calcination be continued for several hours.

The first method I have employed with success, consists in mixing intimately a given quantity of the well-pulverized ore with about three or four times its weight of a mixture made by slaking quicklime with caustic soda, and then drying and calcining the mass. To the intimate mixture of soda, lime, and ore, one-fourth part of nitrate of soda is added. The whole is then well calcined for two hours, taking great care to stir the pasty mass every quarter of an hour with a platinum wire. In consequence of this mixture not becoming fluid, the ore is constantly kept in contact with the oxygen of the atmosphere, and thus becomes decomposed and the oxide of chromium oxidized. I find that, by this method, one treatment is generally sufficient to completely attack the ore. It is seldom that two treatments are necessary, whilst, by the method usually adopted, five or six successive calcinations are required. Henry Rose states that these calcinations may be avoided by weighing the remaining residuum or ore not attacked, and then calculating the chrome in it from that which has been acted upon; but this mode would lead to incorrect results, for chrome ore always contains silica and alumina, which are easily dissolved in the first operation.

The greater part of the mass is now dissolved in water, and to the insoluble portion, sulphuric acid, diluted with twice its bulk of water, is added. When the whole is removed from the crucible, a little alcohol is added to the solution, which renders the sulphate of lime nearly insoluble. The whole is next thrown on a filter and washed three or four times with weak alcohol, which dissolves all the bichromate formed, leaving the sulphate of lime with the ore not attacked on the filter. The former is easily removed by washing the filter with

boiling water. If any ore is left as a residuum, it is recalcined. The solution containing the bichromate of soda is now neutralized with ammonia and oxalate of ammonia added, which gives rise to a small precipitate of sesquioxide of iron, alumina, and oxalate of lime, together with a little silica dissolved by the excess of sulphuric acid. The precipitate having been separated, and well washed, the liquor is either boiled with alcohol to reduce the chromic acid to the state of oxide, to be precipitated and valued; or the liquor is rendered acid, and the amount of chromic acid ascertained by protochloride of tin according to Dr. Penny's process.

The two following analyses of an ore from Turkey were made by this method :

	I.	II.
Sesquioxide of chromium	57.60	58.40
Protoxide of iron	25.78	26.14
Sand, clay, chalk	17.50	16.35

Another process which I have found to produce also good results, consists in calcining the well-pulverized chrome-ore with nitrate of baryta, the oxygen of which, as it leaves it, gradually oxidizes the oxide of chromium. From time to time, towards the end of the operation, a little caustic potash is added, which facilitates the action and gives rise to chromate of potash. The transformation of the oxide of chromium into chromic acid is nicely effected by the pasty state of the fused oxide of barium preventing the ore falling to the bottom of the crucible, and thus becoming excluded from the oxidizing action of the atmosphere. On cooling, the crucible and its contents are put in contact with dilute nitric acid, which dissolves the greater portion of the mass, leaving the non-attacked ore. This residuum after being washed, is ready for a new treatment, if deemed necessary. The liquor containing the bichromates of soda and baryta, nitrate of baryta, peroxide of iron, alumina and lime, is first heated with sulphate of potash, which precipitates the baryta in the state of a sulphate. The precipitate is thrown on a filter and washed; and to the filtrate ammonia and oxalate of ammonia are added, on which peroxide of iron, alumina, and oxalate of lime fall down. The mixed precipitate is gathered on a filter, washed, and the chromium in the chromate determined.

XVIII.—*On certain Isomeric Transformations of Fats.*

BY PATRICK DUFFY,

OF THE BIRKBECK LABORATORY, UNIVERSITY COLLEGE, LONDON.

Chevreul gave the name of stearic acid to a particular acid derivable from certain natural fats, while, at the same time, he used the word stearine as a synonyme for the most solid portion of any natural fat which furnished glycerine; thus, he speaks of the stearine of human fat, while, at the same time, he shows that stearic acid is not derivable from it. Lecanu afterwards prepared from mutton fat a substance which, on decomposition by alkalis, yielded an acid consisting chiefly of stearic acid, and proposed to restrict to this substance the name of stearine. Most chemists, adopting the principle of nomenclature contained in Lecanu's proposal, now understand the names stearine, margarine, &c., to signify bodies which, if they were obtained, would, on decomposition by alkali, furnish respectively only stearic acid, margarine acid, &c., and glycerine, and, in the absence of such substances, apply them to those which most nearly approach them. The origin of this nomenclature for the fats, belongs, however, not to Lecanu but to Chevreul; for, throughout his work on the fats, stearine is the only exception to it. This exception, I wish to remark, has been rather unfortunate: for many physiologists and some chemists, still employing the word in the sense in which Chevreul used it, have particularized by it bodies which other chemists have described as margarine or palmitine. This diversity of nomenclature has already introduced many apparent discrepancies into works upon the fats, and, as a consequence, some real difficulties in the way of further investigation. I refer to the circumstance here, not because I have any change of name to propose, but because I think allusion to it will be sufficient to render obvious the advantages of allowing stearine to signify the substance, whether hypothetical or not, which, on decomposition by alkali, affords stearic acid and glycerine, instead of forming an exception to a convenient and established system of nomenclature.

Chevreul* prepared what he called stearine from five different sources, viz., human fat, fat of swine, fat of the goose, mutton fat, and beef fat. As he gives, instead of the melting point, the point of solidification after melting, and as other chemists, in speaking of the stearine prepared by them, have given only the melting point, we are

* *Recherches Chimiques sur les corps gras.* Paris, 1823, p. 261, &c.

restricted to use, as the standard of comparison for their results, the melting point of the acid furnished on saponification. The acid from the substances prepared by Chevreul, even after the removal of a portion of oleic acid, melted only in one case so high as 64.8°C . Since the melting point of stearic acid, as found by him and confirmed by others, (Redtenbacher,* Laurent and Gerhardt†) is 70° , none of the substances which he called stearine, can be regarded as a close approximation to pure stearine.

Braconnot,‡ by using essence of turpentine as the purifying agent, instead of alcohol, which Chevreul used, succeeded in procuring a substance which melted at 61.25° , and furnished an acid fusible at 62.50° .

Afterwards Lecanu§ prepared from mutton-fat, by means of ether, a substance which melted at 62° , and furnished an acid melting at 64° . He states that he found it impossible to raise the melting point of this acid by purification higher than 66° , and adds that M. Bussy, in researches which he was then pursuing, had not found stearic acid to melt higher than 66° . Hence he concluded that what he called stearine was a pure substance.

Since then stearine has been prepared in the same manner by Liebig and Pelouze,|| who do not mention its melting point in their paper; by Artzbächer,¶ who brought its melting point to 60.6° , and by Heintz,** who agrees with Lecanu in its melting point. Although these chemists may not concur with Lecanu in regarding any of these substances as pure stearine, they yet admit that it is impossible to raise its melting point above 62.25° .

There are three ways in which the chemical purity of the glycerine-fats may be estimated—1st. That further crystallisation produces no change in the melting point of the fat itself; 2nd. That when crystallised, the crystallised portion and that remaining in the mother-liquor differ not at all, or only slightly, in melting point; 3rd. That on saponification, the resulting acid be not susceptible of having its melting point changed, or in other words, of further purification.

The first of these tests is that by which chemists have hitherto been guided in the purification of fats; but although competent, it

* Ann. Ch. Pharm. XXXV, 46.

† Compt. Rend. trav. chim. 1849, p. 337.

‡ Ann. Chim. XCIII, 252. J. Pharm. XXV, [2], 307.

§ J. Pharm. XX, 325. Ann. Ch. Phys. LV, 192.

|| Ann. Ch. Pharm. XIX, 264. J. pr. Chem. 173.

¶ Ann. Ch. Pharm. LXX, 239. Compt. Rend. trav. chim. 1849, p. 343.

** Pogg. Ann. LXXXIV, 229.

is calculated to deceive unless very delicately applied, and, as will be seen, has really done so.

In the treatment of mutton fat by ether for the preparation of stearine, I have found that, although between two successive crystallisations after the fifth, the thermometer can scarcely distinguish, yet if these two crystallisations be melted under the same circumstances, a difference of time in the commencement of melting will be perceived, a difference which is still greater, the more widely separated in respect to the number of times two specimens may have been crystallised; and although the thermometer may fail to point out a difference in the melting point of two immediately successive crystallisations, yet that long after the melting point of stearine has reached 62° , the difference of melting point between substances, one of which has been crystallised two or three times oftener than the other, is quite sensible to the thermometer.

Instead, however, of relying entirely on this test, I took as guide the second, one which consists, theoretically speaking, in carrying on the crystallisation from ether, till the portion which remains in the mother-liquor, has the same melting point as that crystallised out. I say theoretically speaking: for, even after thirty-two crystallisations, the residue in the mother-liquor, after removal of a second crop of crystals, differed in melting point from the first crop by 2° or 3° .

It might be supposed that, instead of the impurities being so persistent as this represents them, the difference of melting point arose from some decomposition taking place every time the substance was dissolved; but this was not the case, for I found the melting point and composition of stearine to remain unchanged after ten weeks' contact and partial solution in ether.

Each of the thirty-two crystallisations spoken of, was made on an average with a quantity of ether at least fifty times that of the substance dissolved, and the mother-liquor was poured off when the temperature fell to 16° . At first the crystals were then washed with warm ether and afterwards strongly pressed by the hands in folds of linen; but as the substance approached to purity this was discontinued, and the mother-liquor removed by decantation alone. A second, and sometimes a third, crop of crystals was obtained from the mother-liquor, and, after being sufficiently purified, added to the first crop. In the first five or six crystallisations, the quantity of ether employed was not more than from ten to fifteen times the volume of the substance dissolved, but towards the end it was increased to upwards of one hundred times the volume. In this manner not more

than eight grammes were obtained from two kilogrammes of the crude fat.

After thirty-two crystallisations, the substance which I obtained melted, not at 62° , but at least 2° higher, and furnished an acid melting at $66^{\circ}5$. It possessed characters hitherto unsuspected in the class of substances to which stearine belongs.

The method of taking the melting point consisted in fusing on a hook at the end of a platinum wire a bead of the substance, and suspending the wire in a beaker containing water previously boiled, to expel air. The temperature of the water in the beaker was regulated by placing the latter on a small sand-bath over a gas-lamp. The perfect contact between the bead and the water ensured the identity of their temperature, which was given by a thermometer suspended in the water. The temperature at which a small ring of limpid fat surrounding the bead first appeared was taken as the melting point. The melting point of substances which, like stearic acid, solidify after fusion, not in an amorphous, but in a crystalline condition, is best observed by enclosing them in thin-walled capillary tubes; for when directly exposed to the contact of the water, the latter entering the interstices among the crystals, and afterwards remaining suspended in the fused mass, gives it an opalescent appearance, and renders it difficult to distinguish the true melting point.

During the preparation of stearine in the foregoing manner, I had occasion to take its melting point at various stages of the purification. Observing that after being melted it did not, in harmony with the laws of latent heat, always solidify at the same temperature as that at which it melted, I made a register of its solidifying point in a number of cases, and found that the solidifying point was, in most cases, from $12\cdot2^{\circ}$ to $12\cdot8^{\circ}$, and never more below the melting point, but in a few cases not even 2° below it. These observations were made long before I had brought the stearine to a state of purity; but although made on an impure substance, they remained good for the purer substance. It was next observed that these variations of the solidifying point were not due to agitation in one case, and its absence in another; in short, that in those cases in which the temperature fell $12\cdot2^{\circ}$ below the melting point before solidification commenced, the passage into the solid condition was not precarious; it was impossible to produce it by any mechanical means at a higher temperature. For those specimens then under examination, the conditions of these variations were found to be, that, when the temperature was raised only 1° or 2° above the melting point, solidification set in as soon as the temperature fell 1° or 2° below the melting point; but that when

the temperature was raised 4° above the melting point, solidification could be induced only when the temperature fell 12.2° below the melting point.

When the stearine which had solidified 12.2° below its melting point was again heated about 1° above the solidifying point, it became less opaque, indeed almost transparent, suggesting the impression that it was melting, but, whether the temperature remained stationary or rose, quickly resumed its opacity. Inasmuch as the precaution of enclosing the fat in dry close tubes made no difference in this phenomenon, it was concluded to be the effect of temperature alone.

In the circumstances of the foregoing experiment, where the fat was continuously heated from below to above the point at which the change presented itself, the conditions were in favour of its appearing at the lowest temperature capable of producing it. As it was shewn to be the effect of temperature, it appeared probable that if the fat were suddenly submitted to a temperature a few degrees higher, but not necessarily so high as the melting point, this appearance would present itself with greater intensity. A bead of substance, of melting point 63° , which was the purest I had at the time, was placed in a small glass tube, at one side of the part which had been previously drawn out to a capillary diameter; the tube was plunged, the end containing the bead undermost, into water at 53.6° ; the air was now sucked out of the other end, whereupon the fat passed through the capillary part of the tube, which, had it not been fluid, it was impossible it could do. Hence, there remained no doubt whatever that the fat really melted at the temperature at which the forementioned transparency appeared, and afterwards solidified at the same or even at a higher temperature.*

The question now arose: is the stearine the same in every respect after as before this melting? that is, has it the same properties, and, among the rest, that of melting at this lower temperature? When taken after melting and again solidifying at 53.6° , and plunged into water at that temperature, it did not melt; in short, it melted only when the temperature rose to its ordinary melting point, 63° . The

* Since I finished my experiments on this point, my attention has been called to the fact that Dr. Heintz, of Halle (Ber. d. Berl. A. 1849, 222. J. pr. Chem. XLVIII, 382. L'Institut. 1849, 390) had also noticed that stearine from mutton fat, melting at 62° — 62.25° , became transparent when immersed in water at 51° — 52° , and afterwards resumed its opacity when the temperature rose to about 58° . He has, however, given no explanation of what takes place, but merely stated that the stearine does not become fluid. His reasons for this conclusion consisted in the fact, that a thin layer of stearine did not change its form, although it became transparent when plunged into water at 52° . In repeating the experiment, I have found that, whenever the stearine becomes entirely transparent, it takes the form that would be assumed by a fused mass of any other substance.

stearine had therefore, by melting and again solidifying at $53\cdot6^{\circ}$, passed into a different isomeric modification. The only evident difference between these two modifications is, that one melts immediately above its solidifying point, the other only at $12\cdot2^{\circ}$ above it, and that the former approaches slightly more to translucency, and is more reflective of light than the latter.

Before melting and solidifying at $53\cdot6^{\circ}$, the stearine had the property of melting at that and even at lower temperatures, so low, that when we take the consequences, instead of the actual appearance, as evidence, we must admit that the proper point for placing the first melting point at is as nearly identical with the point at which it solidifies, after being heated 4° above its hitherto known melting point, as the melting point of any metal is with its solidifying point. What I mean by taking the consequences as evidence is, that the appearance of melting at $53\cdot6^{\circ}$ being succeeded by the transition into a modification which melts only at 63° , if we find that this transition is a consequence of keeping it a sufficient length of time at 51° , then, although we may see no appearance of melting, we must consider that it does melt at that temperature. In the case of this specimen, which melted at 63° , and solidified about $50\cdot5^{\circ}$, it was found that although a temperature of 51° required a long time to produce the change into the modification melting at 63° , it was yet sufficient to do so, and for that reason I conclude that the first melting point is at least within $0\cdot5^{\circ}$ of the solidifying point. A reason why this transition at the lowest sufficient temperature is not preceded by the appearance of melting, consists in the fact "that next to water, fat possesses the greatest capacity for heat;"* and "is also one of the worst conductors of heat when fluid;"† so, that, after the heat of the water in the experiment has melted the surface of the bead, the surface, or say the superficial stratum, will have again solidified in the modified state before the heat has penetrated to the next interior stratum; hence, at the lowest temperature sufficient to produce the change, a portion is always in one or other solid state, and at no one moment is the whole transparent, but only different portions in successive moments.

It will be readily perceived that the temperature of the first melting point is dependent on that of the solidifying point (the solidifying point after heating 4° above the second melting point). As all temperatures above the solidifying point, and below the second melting point produce the modification of higher melting point, if the

* Lehmann's Phys. Ch. translated for Cavendish Soc. by Day, I, 261.

† Id. p. 260.

solidifying point was higher than it is, the first melting point must also have been higher, or it could not have existed at all.

It yet remained to be found what was the cause that, when the temperature had not been raised 4° above the second melting point, solidification set in before the temperature fell 12.2° below this melting point.

This depended on the fact that there was yet another melting point, and another isomeric condition corresponding to it.

When the temperature was raised only 1° or 2° above the second melting point, and then allowed to fall slowly 1° or 2° below it, solidification commenced, and proceeded, not suddenly, as at the ordinary solidifying point, but slowly, and when complete, the appearance of the fat was entirely different from what it had been in either of the foregoing modifications, it was more opaque and friable, and melted only at 66.5° , or 3.5° above its ordinarily known melting point.

To distinguish these different modifications, they will be called in the order of their melting points, the first, second and third; that melting at 51° , the first modification; that melting at 63° , the second; that melting at 66.5° , the third. The latter may be also called the crystalline condition, for it really is so; and what is very remarkable, as well from its connexion with the other facts in this paper, as from its having so long escaped observation, the crystals from ether have the third melting point only.

From what has been said it will be observed, that both the second and third modifications are producible in the interval between the first and second melting points; the second modification in the lower extremity of this interval, the third in the higher. There is, however, no particular point in this interval forming a marked boundary by which the two ranges of temperature that produce the two different modifications are separated. In the case of the specimen taken for illustration, and having its melting points respectively at 51° , 63° , and 66.5° , the second modification was alone producible under 56° , at least within any moderate time; at 56.5° a mixture seemed to be the result, whilst at 57° , and all temperatures between that and the third melting point, the third modification alone was produced.

It may also be collected from what has been stated, that neither the second nor third modification can be produced from a substance which has been heated to the third melting point; for the liquid which is then formed, solidifies only when the temperature falls below the first melting point, and is then necessarily in the first modification, unless after the lapse of hours.

What has been said of the specimen hitherto spoken of, may be summed up by saying that it has three melting points; it melts at the temperature of the first, solidifies; melts at the temperature of the second, solidifies; melts at the temperature of the third, and then solidifies only when the temperature has fallen below all three; and after solidifying here, it may be made to melt again at the first, at the second, and at the third melting points respectively, solidifying, as before, below all three; and these changes are producible in this succession to any extent without the slightest loss or gain of weight.

In specimens where the impurities predominate, as those having their second melting point at 61° , or below it, the third modification is procurable only by obtaining crystals from ether or some other solvent.

On the other-hand, as the stearine approached to purity, the appearance of the second melting point subsided, insomuch that when a substance having its first melting point at 52° , and its third at $69^{\circ}7$, was obtained, it did not, on being heated continuously from the first to the third melting point, become fluid at any intermediate temperature; however, when it was melted at or near its first melting point, and allowed to solidify at the same temperature, and then suddenly removed to a temperature which by inference was judged to be a little above its second melting point, as $65^{\circ}5$, it did melt.

At the same time that the second melting point was thus disappearing, the highest temperature for producing the second modification, instead of rising along with the melting points, was approaching more and more nearly to the first melting point, thus narrowing the limits for the production of the second modification and extending those of the third, so that in the specimen having its first and third melting points at 52° and $69^{\circ}7$ respectively, the highest temperature for producing the second modification was about 55° , or 3° above the first melting point, while in the less pure substance, having its first melting point at 51° , the corresponding point was 56° , or 5° above its first melting point.

These facts, along with the melting point, specific gravity, and external appearance* of the second modification being intermediate between those of the other two, lead to the inference that if stearine were obtained quite pure, the highest temperature at which the second modification would be producible would coincide with the first melting point; and there being consequently no range of temperature for producing the second modification, there would be no second modifi-

* Although the appearance is intermediate, it is quite distinct. It is described further on.

cation and no second melting point, but only a first and third melting point, or in that case, a first and second melting point; and that what I have called the second modification is a mixture of the other two modifications, owing its existence, somehow or other, to the impurities. But even were we certain that this were the case, there would still remain the difficulty of explaining how they could produce it. The following seems to me also a strong reason for believing it not a mixture. In the assumption that it is such, is implied that the relative quantities of the first and third modifications in it are such that when the melting point of the former is exceeded, its solvent action on the latter is sufficient to make the whole melt some distance below the third melting point. Now if this were correct, we ought, by increasing the proportion of the first modification, or, in other words, of the solvent, to be able to depress the melting point of the whole still more. But experiment showed that when a bead of substance having its second melting point at 63° was brought into the second modification by being melted and allowed to solidify at a little above its first melting point, it became limpid at the same temperature, 63° , as it did when it was allowed to solidify, only very partially, or when after solidifying, the greater part of it was again reduced to the first modification.

Dr. Hittorf* has lately shown in an interesting paper on selenium, that this substance has two allotropic modifications and two melting points to correspond; and that, after melting at the higher of the two, it solidifies only when the temperature has fallen considerably below both. Now it is also known that selenium softens considerably below what he calls its first melting point; but whether the changes which accompany this softening are those consequent upon a real fusion, has not been investigated; but should they be found to be such, there would be the closest analogy between its characters and those of stearine.

The following is a short table of the melting-point of mutton stearine at different stages of the purification:

No. of crystallizations.	Solidifying Points.	Melting Points.		
		1.	2.	3.
5	49°	49.5°	61.3°	64°
17	50.5	51	63	66.5
32	51.7	52	64.2(?)	69.7

From this table, it will be observed that the second melting point

* Pogg. Ann. LXXXIV, 214.

risers much more quickly than the first, with the removal of the impurities, and the third still more quickly than either of the other two. This is explained by what we know to be the general action of solvents; for the influence of the impurities is a solvent one, or in other words, one which tends to depress the melting point; and for any given quantity of impurities, this is greater at the temperature of the higher than of the lower melting point, so that this quantity of impurities being removed, the higher melting point rises in consequence more than the lower. The different modifications have probably also different solubilities, even at the same temperature; indeed, the fact of the third modification being always deposited from ether, whatever modification may have been dissolved, shows that it is the one most insoluble in ether. The property in question should, therefore, be ascribed in part to each of these causes.

Considering that in general an increase of specific gravity corresponds to a loss of latent heat, and that doubtless these different modifications of stearine depend on differences of latent heat, it became an object to take their specific gravities with as much precision as possible.*

The following table shows a decided difference in the density of the different modifications. Where two observations on the same substance at the same temperature are given, they were made on different quantities in different bottles as a test of the method. Whatever tem-

* As there are other instances where the method employed might be used with some advantage, a description of it may be useful. A portion of dry stearine was put into a dry stoppered specific gravity bottle and weighed. The bottle was then filled with distilled water, inverted in a beaker containing distilled water, and the whole heated to 100°: in this way the fat melted, and allowed any adhering air, as well as that expelled from the water, to collect in a single globule; after cooling, the bottle was taken out of the beaker, and being placed in its ordinary standing position, the greater part of the globule of air rose into the neck of the bottle, whence it was expelled by filling its place with water. To remove the air which still adhered to the fat, a tube about two inches long, and wide enough to admit the head of the stopper, was attached by a piece of vulcanized caoutchouc tubing to the neck of the bottle, and filled with distilled water. The temperature of the water being about 30° degrees, the apparatus was placed in a beaker, under the receiver of the air-pump. On exhaustion, the remaining air in the bottle rose, by its elastic force, through the orifice in the stopper and through the water in the little reservoir. On readmission of the air to the receiver, the water in the reservoir was forced into the bottle to supply the place of the removed air. The bottle being thus filled was, after removal of the tube, again placed on its side, and the orifice immersed in a beaker of distilled water; by bringing the temperature of the water in the beaker to the required point, that in the bottle was brought to the same, and all the different modifications of the fat successively produced. Before taking the bottle out to weigh it, it is necessary to keep the temperature a considerable time at the point to which the determination refers, otherwise the slow cooling of the fat, arising from its great specific heat and bad conducting power, will occasion serious errors.

perature the determination is referred to, water at the same temperature is the unit.

SPECIFIC GRAVITIES.

3rd M.P. of substance.	Temp. at which determination was made.	Modifications.			
		1.	2.	3.	Fluid.
65°	15°	0·9872	—	—	—
66·5	15	0·9877	—	—	—
69·7	15	0·9867	1·0101	1·0178	—
	15	—	—	1·0179	—
	51·5	0·9600	—	1·0090	—
	65·5	—	—	0·9931	0·9245
	68·2	—	—	0·9746	—

The volumes corresponding to these densities are as follows :

3rd M.P. of substance.	Temp. at which determination was made.	Modifications.			
		1.	2.	3.	Fluid.
65°	15°	1·0129	—	—	—
66·5	15	1·0124	—	—	—
69·7	15	1·0134	0·9900	0·9825	—
	15	—	—	0·9824	—
	51·5	1·0416	—	0·9910	—
	65·5	—	—	1·0069	1·0816
	68·2	—	—	1·0260	—

From these tables it may be seen that the density does not change sensibly with the condition of purity; that the third modification is denser than the second; the second than the first; and, as might be supposed, that the fluid modification is less dense than any of the others; that the first and third, at least, although solids, expand much more rapidly with increase of temperature than does water, a property long known of the liquid fats, but not previously determined, I believe, for any solid fat; that between 15° and 51·5°, the first modification expands more than the third; it is however to be remarked, that at the higher extremity of this interval, the first modification approaches its melting point, which probably influences its rate of expansion. We also observe, that within the range of 2·7° between the temperatures 65·6° and 68·2° the third modification expands 0·0191 parts more than water; within the range of 14° between the temperatures 51·5° and 65·5°, it expands only 0·0159 parts more than water; while within the range of 36·5°, between the temperatures 15° and 51·5°, it expands only 0·0086 parts more than water.

There can be no doubt that a greater number of these data taken

by the more convenient and exact method of a volumenometer, would point out some interesting relations.

None of these modifications conduct electricity. When a small portion of any of them formed part of the circuit of a very intense current produced by a powerful induced magnet with three Daniell's cells, the galvanometer was not sensibly deflected.

Not the least interesting fact, however, is that this property of existing in three modifications is not peculiar to stearine from mutton fat; it is possessed by many other fats.

At the same time that I prepared stearine from mutton fat, I also sought it in beef fat with the view of submitting to investigation the question of the constitution of the glycerine fats in general, as regards their products on saponification, by a method proposed to me by Dr. Williamson. The results of this investigation are reserved for a future communication.

Artzbächer* seems the only chemist besides Chevreul who has attempted to prepare stearine from beef fat. The stearine obtained by him from it melted at $60\cdot6^{\circ}$.

Commencing with the same quantity of it as of the mutton fat, viz., two kilogrammes, I obtained, after eighteen crystallisations from ether, not more than a gramme of substance melting at 63° ; the quantity being now so small, it was useless to pursue the purification further, although the melting point of the residue in the mother-liquor, after removal of a second crop of crystals, was $2\cdot8^{\circ}$ below that of the first crop. It possessed, however, all the properties of mutton stearine of the same degree of purity, so that 63° was only its second melting point.

A substance which is probably a vegetable tallow, but of whose history I know little, has also been the subject of investigation. In its crude state, it is of a pale yellow, cheese-like appearance, somewhat motley from parts of it being crystalline and others waxy; it has a slightly disagreeable smell. On saponification, it yields a dirty white soap which forms a brown solution, and on decomposition by strong acid, liberates an acid of a deep brown colour.

After one crystallisation of this substance from alcohol, and five from ether, there remained a glycerine fat, which melted only $1\cdot2^{\circ}$ higher than the residue in the mother-liquor, so that it is not difficult to purify. Its properties were then analogous to those of stearine, but like the purer stearine, it does not, on being heated continuously from its first to its third melting point, viz., from $45\cdot6^{\circ}$ to $64\cdot5^{\circ}$, melt at any intermediate temperature, but when the temperature comes to 62° , its appearance quickly changes from waxy to crystalline;

* Ann. Ch. Pharm. LXXX, 239. Compt. Rend. trav. chim. 1849, 343.

this, and the results of some experiments similar to those by which the existence of the second modification was shown in stearine after its second melting point had disappeared, make me believe that this substance really has a second melting point at 62° . After melting at the third melting point, it solidifies in less time than does stearine above the first melting point; so that in order to bring it into the first modification, it must be cooled somewhat quickly, in less than an hour at most; but at whatever temperature it solidifies, it has the same properties as if it had been melted as well as solidified at that temperature. This is universally the case; the properties of the solid fat are regulated by the temperature at its own formation, not by that at which the antecedent liquid may have been formed.

The corresponding modifications of this substance, of mutton-stearine and of beef-stearine have the same appearance under the microscope. There is not much to be said of the first modification, unless that it appears as mamillæ radiated like hematite; when watched under the microscope, these mamillæ are seen to form suddenly when the temperature falls to the solidifying point; the second modification has an exfoliated appearance, somewhat suggestive of incipient crystallisation; the third is perfectly crystalline, and by proper attention, particularly in the case of the vegetable fat, the crystals can be obtained in the dry way as definite in form, as from ether, but smaller. So far as the eye can judge without means of measurement, the crystals of these three substances seem isomorphous, but I regret I have not been able to measure their angles.

Palmitine, from palm oil, after twelve or thirteen crystallisations from ether, margarine from butter, and also margarine from human fat, or at least the more solid portion of that substance after two crystallisations from alcohol, and one from ether, exhibited similar phenomena with respect to variety of modification and melting point.

On the other hand, neither claidine, cocinine, nor any other of the substances in the subjoined table, has the property of existing in more than one modification.

In seeking for some feature in the constitution of the substances that have this property, which would separate them from those that have not, the attention is arrested by the fact, that most of the substances which possess it, as stearine, palmitine, margarine, are unquestionably the glycerine-fats, corresponding to certain members of the series of acids of the formula $(CH)_{2n}O_4$. while among those substances which do not possess it, there is not one, unless we except cocinine, which has such a constitution. In reference to cocinine, I may

observe, that although St. Evre's* analysis of cocinine acid agrees with the formula $C_{22}H_{22}O_4$, yet he, as well as Bromci† describe it as destitute of one character, crystallisation and opacity on cooling, which, so far as is known, belongs to every other member of the series of acids to which his formula assigns it.

In the following table, instead of the formula of the fats themselves, are written those of the acids derivable from them; for as yet considerable doubt must exist as to those of the fats. In the other cases the formulæ of the substances themselves are written.

	Formulæ.	Solidi- fying Points.	Melting Points.		
			1.	2.	3.
Mutton-stearine	$C_{34}H_{34}O_4$	51.7°	52.0°	64.2°?	69.7°
Beef-stearine	$C_{34}H_{34}O_4$	50.5	51.0	63.0	67.0
Substance from vegetable tallow	—	45.0	45.6	62.0	64.5
Palmitine from palm oil . . .	$C_{32}H_{32}O_4$	45.5	46.0	61.7	62.8
Margarine from butter . . .	$C_{34}H_{34}O_4$	40.0	40.5	51.0	52.6
Margarine (?) from human fat .	—	43.5	44.2	54.5	56.0
Cocinine	$C_{22}H_{22}O_4$	29.3	33.5		
Elaidine‡	$C_{36}H_{34}O_4$ {	23.7	38.0		
		28.0			
Stearic acid	$C_{34}H_{34}O_4$	65.8	68.0		
Palmitic acid	$C_{32}H_{32}O_4$	59.0	61.0		
Margaric acid from butter . .	$C_{34}H_{34}O_4$	50.5	52.3		
Stearic ether	$C_{38}H_{38}O_4$	33.0	33.7		
Cerotic ether§	$C_{58}H_{58}O_4$	60.0	60.3		
Cerotin (alcohol)	$C_{54}H_{56}O_2$	81.0	81.0		
Cerotene	$C_{54}H_{54}$	57.0	57.8°		
Chinese wax	$C_{108}H_{108}O_4$	80.5	81.0		
Paraffin	$(CH)_{2n}$	43.5	43.5		

XIX.—On the qualitative separation of Arsenic, Tin, and Antimony,

BY GEO. F. ANSELL.

Although a great many processes for the purposes mentioned have been suggested, processes which, in the hands of experienced chemists, will invariably give satisfactory results, a method is still wanted,

* Ann. Ch. Phys. [3], XX, 91. Ann. Ch. Pharm. LXIV, 341.

† Ann. Ch. Pharm. XXXV, 277.

‡ The solidifying point of elaidine is precarious.

§ I am indebted to the kindness of Mr. Brodie for the specimens upon which I operated of the five last-mentioned substances.

sufficiently simple and precise, to admit of being used by the beginner in analytical chemistry. At the suggestion, and under the direction of Dr. Hofmann, I have made a series of experiments upon this subject, and now beg to submit the result to the Chemical Society. The precipitates produced by sulphuretted hydrogen are heated with sulphide of ammonium in the usual way, and the sulphide of ammonium solution reprecipitated with hydrochloric acid and hydrosulphuric acid.

The precipitate thus obtained, which may consist of bisulphide of tin, pentasulphide of arsenic and pentasulphide of antimony, and occasionally of the sulphides of gold and platinum, is redissolved in nitrohydrochloric acid, and the solution poured into an ordinary apparatus for generating hydrogen gas, so arranged as to allow of washing the gas with a dilute solution of acetate of lead, which absorbs any hydrochloric acid or sulphuretted hydrogen, and to pass the mixture of antimoniuiretted and arseniuiretted and free hydrogen into a test-tube half-filled with pure concentrated nitric acid.

If the gas be passed moderately slowly, the whole of the metallic hydrides are decomposed; water, arsenic acid and antimonious acid being formed. The nitric acid solution obtained after the gaseous mixture has passed for about a quarter of an hour, is evaporated; and the residue, after being exposed to a tolerable heat upon a sand-bath, in order to expel the last traces of nitric acid—which is an essential condition of success, inasmuch as antimonious acid is slightly soluble in water containing nitric acid—contains antimonious acid, arsenic acid and arsenious acid.

The residue is now exhausted with warm water, which takes up all the arsenic and arsenious acid. The aqueous solution, when mixed with nitrate of silver and neutralized drop by drop with ammonia, yields, if arsenic be present, a precipitate of arseniate or arsenite of silver. The colour of this precipitate varies to a considerable extent: if the quantity of arsenic be considerable, it presents the pure red of the arseniate of silver; but when the quantity of arsenic is minute in proportion to the amount of antimony, the heat necessary to expel the last traces of nitric acid, reduces part of the arsenic acid to the state of arsenious acid, the silver-salt of which imparts a yellow tint to the precipitate produced by nitrate of silver and ammonia. This change of colour in the precipitate is an inconvenience, but it does not materially affect the value of the method; since, in a carefully conducted operation, the formation of any precipitate whatever indicates the presence of arsenic.

The residue which is left after complete exhaustion with water is antimonious acid. It is dissolved in the smallest amount of nitro-

hydrochloric acid; in the ordinary analysis, the quantities are frequently so minute that it is advisable to boil filter and all in aqua regia; the excess of acid is evaporated as far as possible, and the remaining solution is mixed with sulphuretted hydrogen water. If a trace of antimony be present, the liquid at once assumes an orange-yellow colour, and on boiling, decidedly orange-yellow flakes are separated.

The method was repeatedly tried by myself and by several of my fellow-pupils, with mixtures in which either one milligramme of arsenic was associated with ninety-nine milligrammes of antimony, or *vice versâ*, one of antimony with ninety-nine of arsenic. Both arsenic and antimony could be detected without difficulty if the operations were carried out with the necessary precautions.

The detection of tin presents no difficulty. The whole of this metal remains in the apparatus for generating hydrogen, either in the form of protochloride, or in the shape of a finely-divided metallic precipitate. If the quantity of tin is considerable, it is sufficient to filter the liquid in the apparatus, and to add to the filtrate protochloride of mercury. A white precipitate of subchloride of mercury indicates the presence of tin. Should this experiment yield no result, the metallic precipitate (tin with a portion of antimony and arsenic) is detached from the plates of zinc, and dissolved in hydrochloric acid, and the solution tested by protochloride of mercury.

It need scarcely be mentioned, that both the sulphuric acid and the zinc used in this operation must be perfectly free from arsenic, tin and antimony.

Note.—This operation is more successful if the nitric acid be kept hot during the time that the gases are passing, but this is not by any means necessary.*

If antimony be present, the nitric acid will soon become opaque, and after a few minutes deposit a white precipitate.

* Mr. Ansell's mode of testing, which is particularly calculated for small quantities of antimony, may be conveniently combined with an additional experiment for arsenic. Incredibly minute quantities of the latter element, even in the presence of a very large amount of antimony, are *readily* and *infallibly* recognized by passing the mixture of antimonuretted and arseniuretted hydrogen into nitrate of silver. As is well known, the whole of the antimony is precipitated in the form of antimonide of silver (Sb Ag_3), while every trace of arsenic remains in solution, in the form of arsenious acid. On neutralizing the liberated nitric acid by ammonia, the characteristic yellow arsenite of silver is precipitated. If the gas has been passed for a long time, the solution is sometimes free from silver. In this case, the silver precipitate of course appears only after the addition of a drop of nitrate of silver.

The separation of the antimony from the black precipitate, which is a mixture of metallic silver and antimonide of silver, is attended with difficulties; and I find it more convenient to use Mr. Ansell's method for the detection of minute quantities of antimony.—A. W. H.

XX.—*Observations upon a new series of Double Chlorides containing Diplatosammonium.*

BY G. B. BUCKTON, F.L.S.

The consideration of the action of cyanogen upon diplatosamine, communicated on a former occasion, has induced me to undertake some experiments with a view to the preparation of that base in combination with cyanic acid. In the course of this examination, I have been led to the discovery of a new series of double salts, which appear to offer some interest. A description of these salts, together with some remarks upon chloride of diplatosammonium with chromic acid, forms the subject of the present paper.

CHLORIDE OF DIPLATOSAMMONIUM AND CHLORIDE OF LEAD.

My attention was first directed to the white crystalline precipitate which falls abundantly on mixing concentrated solutions of chloride of diplatosammonium with acetate or nitrate of lead. After washing the mass, it was dissolved in boiling water and filtered whilst hot. The substance reappeared on cooling, in the form of small quadrilateral plates of a pearly lustre, which often were sufficiently thin to reflect the colours of the soap-bubble. When gathered on a filter, they appeared as a mass of frosted silver, and the dry crystals resembled those of cholesterine.

As this substance did not decompose at a heat below 170° C., the portions set apart for analysis were all dried at a temperature between 110° and 120° .

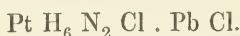
I.	0.5948	gms. of substance gave
	0.5612	„ „ chloride of silver, equal to
	0.1388	„ „ chlorine.
II.	0.5308	„ „ substance gave
	0.5006	„ „ chloride of silver
	0.1238	„ „ chlorine.
III.	0.5700	„ „ substance gave
	0.5326	„ „ chloride of silver
	0.1317	„ „ chlorine.
IV.	0.6042	„ „ substance gave
	0.2976	„ „ sulphate of lead, equal to
	0.2033	„ „ lead. The filtrate by ignition gave
	0.1974	„ „ platinum.

- V. 0.6648 gms. of substance gave
 0.3271 „ „ sulphate of lead
 0.2235 „ „ lead.
- VI. 0.7586 „ „ substance burnt with oxide of copper
 0.1456 „ „ water, equal to
 0.0161 „ „ hydrogen.
- VII. 0.7530 „ „ substance, with soda lime, gave
 1.0820 „ „ platino-chloride of ammonium, or
 0.0678 „ „ nitrogen.

From which numbers the following per-centages are calculated :

	I.	II.	III.	IV.	V.	VI.	VII.
Chlorine	. 23.34	23.32	23.10	—	—	—	—
Lead	. —	—	—	33.48	33.62	—	—
Platinum	. —	—	—	32.67	—	—	—
Hydrogen	. —	—	—	—	—	2.13	—
Nitrogen	. —	—	—	—	—	—	9.0

which correspond to the formula :



The theoretical and experimental per-centages are as follows :

	Theory,		Experimental mean.
Pt	. .	99.00 32.19	32.67
H ₆	. .	6.00 1.95	2.13
N ₂	. .	28.00 9.10	9.00
Pb	. .	103.56 33.67	33.55
Cl ₂	. .	71.00 23.15	23.25
		307.56 100.00	100.60

This substance is insoluble in alcohol, and also in hydrochloric acid. Concentrated sulphuric acid freely liberates fumes of hydrochloric acid, sulphate of lead being thrown down. Hydrosulphuric acid isolates chloride of diplatossammonium, with evolution of hydrochloric acid and precipitation of sulphate of lead, which, however, always carries down a portion of platinum, and renders it necessary to estimate the lead in the above analysis as sulphate, by adding sulphate of ammonia and free sulphuric acid.

A convenient method of preparing this salt, presented itself as a matter of course in the direct union of the two chlorides, the combination being promoted by adding hydrochloric acid, which facilitates also the regular crystallisation.

In the case of precipitation by acetate of lead, as might have been foreseen, the mother-liquor yielded on concentration, crystals of acetate of diplatosamine, to identify which, the substance was converted into chloride by adding hydrochloric acid, evaporated to dryness, and after solution in water, precipitated by alcohol. The platinum obtained by ignition left no doubt of the composition of this salt.*

The deportment of chloride of diplatosammonium with chloride of lead, induced me to study several other double compounds of this substance.

CHLORIDE OF DIPLATOSAMMONIUM AND PROTOCHLORIDE OF MERCURY.

This substance falls as a bulky crystalline salt, which is easily soluble in boiling water, from which, after filtration, it recrystallises in plumose groups composed of a multitude of cubes. The solution, when rapidly cooled, yields nacreous plates, not unlike those of the lead-salt. This substance, like all those hereafter described, produces more regular forms from an acid than from a neutral solution; and its insolubility in hydrochloric acid may be seen by its addition causing a partial precipitation in the saturated aqueous solution.

I.	0.6574	gms. of salt dried at 120°, gave on ignition
	0.2130	„ „ platinum.
II.	0.5022	„ „ salt gave
	0.1640	„ „ platinum.
III.	0.5156	„ „ salt gave
	0.4874	„ „ chloride of silver, equal to
	0.1205	„ „ chlorine.
IV.	0.5196	„ „ salt gave
	0.4880	„ „ chloride of silver
	0.1207	„ „ chlorine.

From these numbers the following per-centages are deduced :

	I.	II.	III.	IV.
Platinum . . .	32.49	32.65	—	—
Chlorine . . .	—	—	23.37	23.23

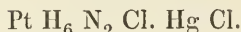
* 0.4050 gms. of substance gave
0.2838 „ „ platinum.

The theoretical and experimental per centages are for,

Pt H₆ N₂ Cl

	Theory.	Experiment.
Platinum . . .	58.75	58.51

which are in accordance with the formula :



The numbers required by theory and obtained by experiment are annexed for comparison.

		Theory.		Experimental mean.
Pt	.	99.0	32.58	32.57
H ₆	.	6.0	1.97	—
N ₂	.	28.0	9.21	—
Hg	.	100.0	32.39	—
Cl ₂	.	71.0	23.35	23.30
		304.0	100.00	

This compound bears a considerable temperature without decomposition. At a certain point it fuses, emitting dense fumes of chloride of ammonium and chloride of mercury. The residue, after ignition, consists of a compact foil of pure platinum, which lines the vessel in which the operation is made.

CHLORIDE OF DIPLATOSAMMONIUM AND SESQUICHLORIDE OF IRON.

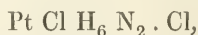
The union of these solutions does not result in the formation of a double chloride; but a yellowish granular substance is deposited, nearly insoluble in water and in ammonia. This salt yields a yellow solution with caustic potash, from which it is again thrown down by addition of hydrochloric acid. The potash solution liberates ammonia on boiling, and the dry salt disengages hydrochloric acid when treated with sulphuric acid.

- I. 0.3978 gms. of substance, dried at 110° gave on ignition
0.1922 „ „ platinum.
- II. 0.3970 „ „ substance gave
0.1930 „ „ platinum,

corresponding to the per-centages :

	I.	II.
Platinum	48.31	48.61

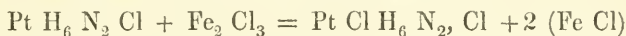
This salt is therefore the chloride of Gros' radical



which requires the following theoretical numbers.

	Theory.	Mean of Experiment.
Platinum	48.41	48.46

After precipitation of the iron solution by an excess of the platinum-salt, it will no longer strike a black colour with tincture of galls; and ferrocyanide of potassium also throws down a nearly colourless precipitate, thus proving that the iron has been reduced from the sesquichloride to the protochloride, the disengaged equivalent of chlorine having united itself to the platinum-chloride thus :



The salts of protoxide of iron do not appear to be acted upon chloride of diplatosammonium.

CHLORIDE OF DIPLATOSAMMONIUM AND CHLORIDE OF ZINC.

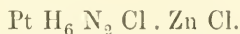
On mixing the concentrated solutions, a very soluble salt falls, which may be recrystallised in colourless plates, possessing the general characters of the substances previously described. It may be conveniently purified by precipitation from the aqueous solution by alcohol, and after drying the mass, reproducing the crystals from boiling water. This substance was dried at 110° , and gently heated with carbonate of soda. After washing the mass with water, it was digested with sulphuric acid, and the platinum-black produced was ignited and weighed.

- I. 0.6562 gms. of substance gave
 0.2734 „ „ platinum.
 II. 0.5176 „ „ substance
 0.6282 „ „ chloride of silver, or
 0.1554 „ „ chlorine.

The calculated per-centages are for :

	I.	II.
Platinum . . .	41.66	—
Chlorine . . .	—	30.02

which agree with the formula



The theoretical and experimental numbers for 100 parts are :

	Theory.		Experiment.
Pt . . .	99.00	41.86	41.66
H ₆ . . .	6.00	2.54	—
N ₂ . . .	28.00	11.84	—
Zn . . .	32.52	13.74	—
Cl ₂ . . .	71.00	30.02	30.02
	236.52	100.00	

CHLORIDE OF DIPLATOSAMMONIUM AND CHLORIDE OF COPPER.

This double compound is immediately formed on mixing the two concentrated solutions. After washing the precipitate from the copper-salt, which should be in slight excess, and drying it at 100° , it has a beautiful olive-green colour, and is composed of yellow plates possessing a metallic lustre. As this salt is decomposed by boiling water, it cannot be purified by recrystallisation, which perhaps may be taken as some apology for the following numbers, which are only approximative, yet sufficiently near to establish the formula.

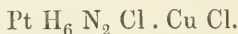
A weighed portion was gently ignited with carbonate of soda, until all ammonia was driven off; and after washing the mass, it was dissolved in nitrohydrochloric acid, concentrated, and then treated with chloride of ammonium and a large excess of alcohol. The platinum was determined by igniting the ammonio-bichloride obtained, and the copper was estimated from the filtrate by adding potash with the usual precautions.

I.	0.7600	gms. of substance gave
	0.3166	„ „ platinum, and
	0.1364	„ „ oxide of copper or
	0.1088	„ „ copper.
II.	0.6458	„ „ substance gave
	0.1126	„ „ oxide of copper or
	0.0898	„ „ copper.
III.	0.6948	„ „ substance gave
	0.2875	„ „ platinum.

The per-centages are :

	I.	II.	III.
Platinum .	41.65	—	41.37
Copper .	14.31	13.90	—

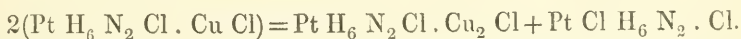
From which is deduced the formula :



The theoretical and experimental numbers are :

	Theory.		Experimental mean.
Pt . .	99.00	41.90	41.51
H ₆ . .	6.00	2.54	—
N ₂ . .	28.00	11.85	—
Cu . .	31.66	13.41	14.10
Cl ₂ . .	71.60	30.30	—
	236.26	100.00	

Previous to solution in water, the crystals of this substance become colourless, and on applying heat, a heavy granular salt is formed, which exhibits all the reactions of Gros' chloride. The supernatant fluid, which becomes of a pale green hue, after sufficient concentration, is precipitated by alcohol in the form of greenish films, which may be regarded as the corresponding salt of the subchloride of copper and diplatosammonium, as an exactly similar substance results from the union of these bodies, a hydrochloric solution of the former being employed. The reaction therefore appears to be similar to that observed in the case of sesquichloride of iron. The change may be thus expressed in the form of an equation :*



The double salt containing the chloride of copper is easily soluble in potash with which it forms an intense blue. It is decomposed by heat, with deposition of oxide of copper.

CHLORIDE OF DIPLATOSAMMONIUM AND PROTOCHLORIDE OF TIN.

On adding an acid solution of the latter to the platinum-salt, a white voluminous precipitate falls, which is easily dissolved by heat ; and the solution again deposits delicate films on standing, which possess the external character of the compounds previously described. The crystals, however, in this case, are always more or less coloured by binoxide of tin.

This decomposition is hastened by heating the solution, which turns to a deep port-wine red colour, and deposits a powder composed of reduced platinum and binoxide of tin, chloride of ammonium being formed at the same time.

CHLORIDE OF DIPLATOSAMMONIUM AND BICHLORIDE OF TIN

may be obtained in a dry state by precipitation in a strong acid solution, and subsequently washing the mass, first with hydrochloric acid and then with alcohol. From the difficulty in obtaining these salts of tin in a sufficient state of purity, no attempt was made to obtain a quantitative analysis.

Chloride of diplatosammonium and chloride of barium throw down from their saturated solutions a crystalline precipitate, which proved to be merely the latter salt, isolated by the difference of its affinity for water.

* This equation probably does not express the whole reaction, as a secondary product may be obtained in small quantity from the filtrate in acicular groups.

Nitrate of suboxide of mercury does not form any double compound when added to chloride of diplatosammonium; and no union of chloride of silver with the latter substance could be effected, even when it was previously dissolved in ammonia.

BICHROMATE OF DIPLATOSAMINE.

Considering the well marked affinities of this base, I was curious to study its behaviour under the influence of chromic acid, thinking it not improbable that an interesting product of oxidation might arise from the action.

Chromic acid forms, with chloride of diplatosammonium, an abundant yellow precipitate, sparingly soluble in cold water, and resembling chromate of lead. From a hot solution it is deposited in minute cubic grains, which are insoluble in alcohol, and appear to be unaffected by dilute sulphuric acid. They do not contain chlorine; but hydrochloric acid is found in the filtrate, after precipitation of the yellow salt.

For analysis, advantage was taken of the peculiar action of alcohol and hydrochloric acid upon the solution of this substance, which in boiling is resolved into sesquichloride of chromium, aldehyde, and a crystalline substance, which proved to be the chloride of Gros' radical.*

As the substance is slightly decomposed at 100° , the salt was dried *in vacuo*, dissolved in water, reduced by alcohol and hydrochloric acid, evaporated nearly to dryness, and seven or eight times the volume of alcohol added to render the platinum-salt insoluble. After standing, this salt was filtered off and ignited, and the sesquioxide of chromium subsequently precipitated from the filtrate by ammonia. In another instance, the chromic acid was precipitated by acetate of lead, and the platinum was obtained by igniting the salt in the filtrate.

I.	0.6366	gms	of substance gave
	0.8443	„	„ chromate of lead equal to
	0.1451	„	„ chromium and
	0.2594	„	„ platinum.

* 0.5290 gms. of this substance gave, on ignition
0.2566 „ „ platinum.

The chloride of Gros' salt ($\text{Pt Cl H}_6 \text{N}_2 \cdot \text{Cl}$) requires

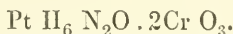
	Theory.	Experiment.
Platinum	48.41	48.50

II.	0.5448	gms.	of substance gave
	0.1776	„	„ sesquioxide of chromium or
	0.1238	„	„ chromium and
	0.2224	„	„ platinum.
III.	0.7498	„	„ substance produced
	0.2381	„	„ sesquioxide of chromium
	0.1669	„	„ chromium and
	0.3037	„	„ platinum.

The per-centage composition :

		I.	II.	III.
Chromium	.	22.79	22.72	22.26
Platinum	.	40.74	40.08	40.51

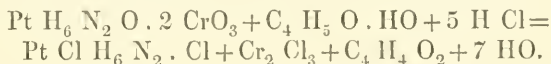
This substance is, therefore, the bichromate of diplatosamine, the formula of which is :



For comparison, the numbers required by theory and the mean by experiment are subjoined :

		Theory.		Experimental mean.
Pt	.	99.0	40.35	40.44
H ₆	.	6.0	2.44	—
N ₂	.	28.0	11.41	—
Cr ₂	.	56.3	22.95	22.59
O ₇	.	56.0	22.85	—
		245.3	100.00	

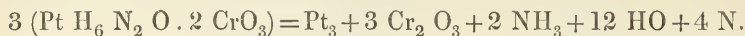
From these numbers it appears that the salt is anhydrous, and so far it has the anomalous constitution of the corresponding potash and ammonia compounds. The decomposition effected by alcohol and hydrochloric acid is represented by the following equation :



I have failed in obtaining more than two-thirds of the calculated nitrogen by igniting the substance with soda-lime; and no increase was observed by addition of a small quantity of sugar previous to burning. An explanation is found in the fact, that pure nitrogen is energetically liberated when the salt is gently heated. The decomposition is accompanied with scintillation, and the products are a black powder composed of platinum and sesquioxide of chromium,

nitrogen, water, and ammonia. The salt may also be kindled by live charcoal in a similar manner to gunpowder.

The following equation represents this reaction :



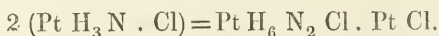
An exactly similar decomposition was first observed by Hayes in the bichromate of ammonia; and the subject has since been more fully investigated by Messrs. Richmond and Abel.

Monochromate of diplatosamine is formed on crystallising the bichromate from an ammoniacal solution, when it is sometimes deposited in pale yellow groups of crystals having the lustre of floss-silk; at other times it forms large cubical masses.

The analyses of this substance have not been very concordant; but nevertheless, the numbers are such as to leave little doubt of the formula being represented by $\text{Pt H}_6 \text{ N}_2 \text{ O} \cdot \text{Cr O}_3$. The behaviour of this compound is similar to that of the bichromate, and like that salt, it is soluble in potash, which does not liberate ammonia until it is boiled.

From the foregoing remarks, it will be seen that chloride of diplatosammonium does not, in the generality of cases, follow the order of double decomposition; but that a direct combination of the two chlorides in the above-mentioned instances ensues, even when the precipitant does not happen itself to be a chloride. The platinum-radical has also a marked tendency to form these double compounds, as it appears to be immaterial whether sulphate of diplatosamine be employed to precipitate chloride of copper, or sulphate of copper be used with chloride of diplatosammonium.* The mercury-salts also seem to give the same result under like circumstances.

The composition of these double chlorides is satisfactorily borne out by the observation of Peyrone, that Magnus' green compound is immediately formed on mixing chloride of diplatosammonium with a hydrochloric solution of protochloride of platinum. Magnus' compound may be thus regarded as a binary salt of this series :



Reiset also has described and analysed the red (yellow?) compound containing the bichloride of platinum, the existence of which might have been foreseen after the existence of the above described bodies had been established.

* In this case, the precipitated salt is nearly colourless, unless a little free hydrochloric acid is present.

XXI.—*On the Acid Oxalates of the Earths.*

BY EDWARD CLAPTON.

In the *Annales de Chimie* [2] LXXIII, 263, M. Berard describes a crystalline oxalate of baryta, which he found to contain 45·04 per cent of baryta, and accordingly viewed as consisting of the earth combined with twice the amount of oxalic acid contained in the neutral oxalate.

M. Darracq had also previously observed a binoxalate of baryta.*

A superoxalate of strontia, of doubtful composition, has since been described by Dr. Thompson.

There have been, however, more recently, some doubts cast upon the existence of superoxalates of this class of oxides; but the investigations about to be detailed show that they can easily be procured in a distinct and definite form.

ACID OXALATE OF BARYTA.

When about equal quantities of saturated solutions of oxalic acid and chloride of barium are mixed together, no cloudiness appears at first; but after the lapse of perhaps a minute, crystals begin to form, and presently they fall in abundance. The crystals are very acute rhomboidal plates; they are soluble in 336 parts of cold water at 60°, the solution reacting and tasting strongly acid; hot water decomposes them. When treated with a solution of ammonia, an oxalate of ammonia is formed, leaving behind oxalate of baryta. Potash acts similarly. The salt is not affected by alcohol or ether. After having been dried *in vacuo*, the salt loses nothing at 212° F., but by a heat of 350° F., water is given off; it loses oxalic acid at about 400° F. Subsequently it is converted into carbonate, with evolution of carbonic oxide.

In order to determine the composition of this salt, the following analyses were made:

- I. 14·15 grs. of salt, dried *in vacuo*, were dissolved in dilute acid, and the baryta was precipitated by sulphuric acid. 9·8 grs. of sulphate of baryta were obtained.
- II. 12·6 grs. of a different preparation similarly treated, gave 8·9 grs. of sulphate of baryta.
- III. 22·41 grs. heated to redness, yielded 13·2 grs. of carbonate of baryta.

* *Ann. Ch. Phys.* [2] XL, 69.

These results give the following per-centage amounts of baryta :

	I.	II.	III.	Average.
Baryta . .	45·5	46·35	45·74	45·86

This accords well with the amount of baryta as calculated from the formula, $\text{BaO} \cdot \text{C}_2 \text{O}_3 + \text{HO} \cdot \text{C}_2 \text{O}_3 + \text{HO}$:

Baryta . . .	45·98
Oxalic acid . .	43·22
Water . . .	10·80
	100·00

The mere heating of the salt at given temperatures, so as to drive off its various constituents, did not give very accurate numerical results ; the loss at 350°F . upon 22·41 grs. in an experiment of this character, was 1·61 instead of 1·21 ; at 400°F . it was 7·91. instead of 7·26.

An organic combustion of the salt was made. 12·75 grs. yielded 6·38 grs. of carbonic acid, and 1·6 grs. of water. The per-centage of carbonic acid is here 47·7, instead of 52·8, the loss being doubtless caused by the retention of some carbonic acid by the baryta in the tube. The amount of hydrogen in this, as also in another experiment, where 24·63 grs. yielded 3·15 grs. of water, little exceeds the calculated amount.

1st. Experiment.	2nd. Experiment.	Calculated.
1·39 per cent.	1·42 per cent.	1·2 per cent.

ACID OXALATE OF STRONTIA.

Upon mixing together strong solutions of oxalic acid and chloride of strontium, crystals presently fall, which are found to be of a mixed kind, presenting large rhomboidal crystals and small octahedra.

The general characters of the salt are similar to those of the acid baryta-salt.

When heated to 212° , many of the crystals became white in colour, and water was given off, having in some instances a slight acid reaction.

The following estimations of the base were made :

- I. 18·45 grs. dried at 212° yielded 12·8 of carbonate of strontia.
- II. 33·5 grs. of a different preparation yielded 21·45 grs. of the carbonate.
- III. 19 grs. of a portion which had crystallized slowly from the solution, after the first crop of crystals had subsided, yielded 11·3 grs. of the carbonate.

IV. 10 grs. dried *in vacuo*, gave off 0·85 grs. of water at 212° F., and yielded 5·8 grs. of the carbonate.

V. 5·55 grs. of the salt prepared by recrystallising the acid oxalate from solution in hot oxalic acid, yielded 3·4 grs. of the carbonate.

These results are very discordant, giving respectively the following percentage amounts of strontia :

	I.	II.	III.	IV.	V.
Strontia . .	48·7	45	41·79	44·55*	43·2

The amount of strontia is, therefore, in every instance less than would be given by the neutral oxalate, viz., 49 per cent, but it exceeds that required by the formula $\text{SrO} \cdot \text{C}_2\text{O}_3 + \text{HO} \cdot \text{C}_2\text{O}_3 + \text{HO}$, viz. 36·6 per cent., or $\text{SrO} \cdot \text{C}_2\text{O}_3 + \text{HO} \cdot \text{C}_2\text{O}_3$, viz., 39·1 per cent. However, in the third experiment the discrepancy is small. In all probability, each sample of salt was a mixture of salts of different compositions ; but there can be no doubt whatever that they contained at least one acid oxalate of strontia.

LIME-SALT.

An attempt was made to produce an acid oxalate of lime by similar means, but without success ; the precipitate which fell had the appearance of neutral oxalate of lime, and 6·15 grs. dried at 212° yielded 4 grs. of carbonate of lime ; the amount obtained from a substance of the formula $\text{CaO} \cdot \text{C}_2\text{O}_3 \cdot \text{HO}$ would be 4·2 grs.

MAGNESIA-SALT.

Very strong hot solutions of sulphate of magnesia and oxalic acid were mixed together. A white powder separated which was almost insoluble in water ; upon heating it, water was quickly driven off ; and by a red heat, it was found that 8·97 grs. yielded 2·69 grs. of magnesia, agreeing with the formula of the simple oxalate $\text{MgO} \cdot \text{C}_2\text{O}_3 \cdot \text{HO}$, which would have given 2·82 grs.

Dr. Gladstone, who has kindly watched over the progress of this investigation, desires me to append the following remarks upon the theoretical bearing of these results :

“A principal point of interest connected with these acid salts, is the corroborative evidence they afford of the bibasic character of the contained acid.

“Oxalic acid may well be viewed as the first member of the series

* Calculated as dried at 212° .

$C_n H_{n-1} O_4$, or (viewing them as bibasic) $C_n H_{n-1} O_8$. This series advances by the addition of multiples of the increment $C_2 H_2$: the superior members are succinic, adipic, pimelic, suberic, and sebacic acids. Pyrotartaric acid also has claims to be considered one of the same group. The properties common to these acids as well as oxalic acid, are their general production by the violent oxidation of organic substances; their resisting most methods of oxidation; their being solid and crystalline at ordinary temperatures; but capable of fusion and sublimation though partially decomposed if rapidly heated; and their tendency to form acid as well as neutral salts, and amidic acids as well as amides. Late investigations have tended to show that these acids should be considered bibasic; the arguments which have led to this conclusion apply equally to oxalic acid. The rational formula of the crystalline oxalate of baryta is, therefore,



"The series formed by the above-mentioned hydrated acids is as follows:

Oxalic acid	.	.	.	C_4	H_2	O_8
Succinic	.	.	.	C_8	H_6	O_8
Pyrotartaric	.	.	.	C_{10}	H_8	O_8
Adipic	.	.	.	C_{12}	H_{10}	O_8
Pimelic	.	.	.	C_{14}	H_{12}	O_8
Suberic	.	.	.	C_{16}	H_{14}	O_8
...				.	.	.
Sebacic	.	.	.	C_{20}	H_{18}	O_8 "

XXII.—*Researches on the Anhydrous Organic Acids,*

BY CHAS. GERHARDT.

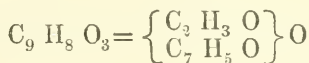
(Continuation from a Letter to Dr. WILLIAMSON.)

In continuing the researches of which I had the honour of communicating the commencement to the Society, I have found a valuable reagent not yet used in organic chemistry, and extremely valuable for the preparation of various chlorides used in the formation of anhydrous acids. This reagent is the oxychloride of phosphorus, $PO Cl_3$, a liquid which effects the decomposition of a great number of salts as easily as it decomposes water, and enabled me, among other things, to prepare *Acetic chloride*,

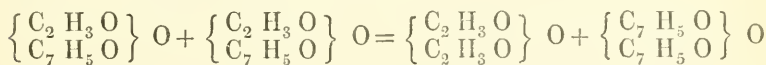


a colourless liquid, very mobile, and boiling at 56° C. It fumes slightly in the air, and is decomposed by water into acetic and hydrochloric acids. With this new chloride, I have obtained several new active compounds by double decomposition.

I prepare *acetic benzoate* or *benzoic acetate* by the action of acetic chloride on dry benzoate of soda, $C_7H_5O_2Na$. The reaction is very brisk, and is soon completed without the aid of external heat. The syrup produced, washed with water and carbonate of soda, leaves an oil heavier than water, neutral to test-paper, and possessing an agreeable odour of Spanish wine. This oil is easily purified from water and other foreign matters by agitation with ether free from alcohol; and after the ether has been removed by a gentle heat, the product shows by analysis, the composition :

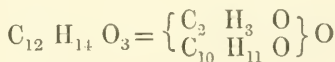


Boiling water renders it acid, but the complete decomposition requires a long action; and the intervention of alkalies is needed, as in the case of ethers. When subjected to distillation, acetic benzoate separates at about 150° into *anhydrous acetic acid* (*acetic acetate*) and *anhydrous benzoic acid* (*benzoic benzoate*). There is evidently a double decomposition between two molecules :

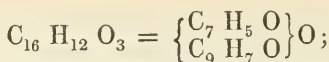


This reaction perfectly explains the formation of anhydrous acetic acid, as described in my last communication (from benzoic chloride and acetate of potassium).

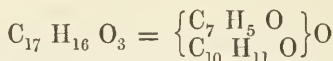
Acetic cuminate or *cuminic acetate*, is obtained in the same manner as the above anhydride. Freshly prepared, it is a fragrant oil, which preserves its liquid form in a stoppered bottle; but a few moments contact with the air is sufficient to make it crystallise, magnificent needles being formed, until the mass assumes the appearance and consistency of frozen olive oil. Analysis shews that this change of state is accompanied by no change of composition of the body :



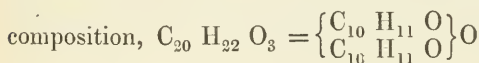
I have also succeeded in preparing in a state of purity, *benzoic cinnamate*, or *cinnamic benzoate*, a heavy, almost inodorous oil, containing



as well as the *benzoic cuminate* or *cuminic benzoate*, a similar heavy oil, containing:

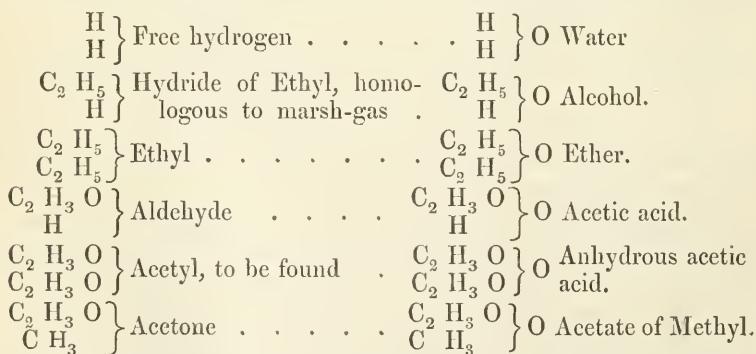


Finally also, *anhydrous cuminic acid*, or *cuminic cuminate*, is obtained by the same process, in the form of a heavy oil, resembling a fatty oil, and possessing a very faint smell. This oil also crystallises after a time; but the oil and the crystals present the same



I am continuing these experiments with butyric, valerianic, and nitrobenzoic acids, and hope soon to be able to communicate my results to the Society.

In concluding this notice, I wish to call the attention of chemists to a remarkable analogy which exists between certain organic compounds belonging to the type water, and certain others, which I compare to the type hydrogen, as represented by the following parallel, which I submit to the consideration of experimenters.



This comparison enables me to foretel that acetyl, and in general those oxygenised groups which act like hydrogen (oxygenised radicals), will be obtained by the reaction of the corresponding chlorides on the metallic aldehydates; and in like manner the ketones, by acting on the metallic aldehydates by the hydrochloric ethers. The experiments and considerations published on this last point by M. Chancel seem to me quite decisive.

NOTICES

OF

Papers contained in other Journals.

**Report upon "Original Gravities,"
By Professors Graham, Hofmann, and Redwood.**

ADDRESSED TO THE CHAIRMAN OF THE BOARD OF INLAND REVENUE.

SIR,

The subject of the present inquiry is the specific gravity of the worts of beer. When worts are fermented they lose in density, and assume, as beer, a different specific gravity. This last is of course the only true specific gravity of the beer, but the specific gravity of the worts is also named with reference to the beer, as the original specific gravity of the beer, or the original gravity of the beer.

A knowledge of the original gravity of beer is required to fix the drawback allowed upon beer when exported, according to the terms of 10th Victoria, cap. 5. By this Act a drawback is granted of five shillings per barrel of thirty-six gallons, upon beer exported, of which "the worts used before fermentation were of not less specific gravity than 1·054, and not greater specific gravity than 1·081;" and a drawback of seven shillings and sixpence per barrel upon beer, of which "the worts used before fermentation were not of less specific gravity than 1·081."

The original gravity of beer is directly observed by the brewer only, who ascertains the specific gravity of the worts of each brewing operation by means of the saccharometer, or other form of the hydrometer, and preserves a record of the observation. To enable the revenue officer to arrive independently at the same information, he possesses the beer only from which to infer the specific gravity of the worts. It is the special object of the following investigations to discover how the original gravity of beer may be ascertained most accurately from the properties of the beer itself.

The question has already been examined by foreign chemists—by Otto and Zenneck, and especially by Balling of Prague; as well as by Messrs. Dobson and Phillips of the department of Inland

Revenue, whose previous researches have greatly facilitated the present inquiry.

The same properties of the beer have been generally had recourse to as likely to throw light upon the original gravity of the liquid, and obviously suggest themselves. These are—1°, the specific gravity of the beer itself (the beer gravity); 2°, the proportion of alcohol the beer contains (the spirit-indication of the beer), to be ascertained by distillation and other practical methods; and 3°, the proportion of unfermented solid matter held in solution by the beer (the extract or extractive matter of the beer). The liquid from which the volatile alcohol has been expelled, and which contains the extractive matter, when made up again to the original volume of the beer by the addition of the necessary quantity of water, represents the beer without its spirit; and it is by the greater or less specific gravity of this liquid that the proportion of extract in the beer has been generally estimated. The extract gravity of the beer is thus obtained.

As the alcohol of the beer is derived from the decomposition of saccharine matter only, and represents approximately double its weight of starch-sugar, a speculative original gravity might be obtained by simply increasing the extract gravity of the beer by that of the quantity of starch-sugar known to be decomposed in the fermentation. The inquiry would then reduce itself to the best means of ascertaining the two experimental data, namely, the extract gravity and the proportion of alcohol in the beer, particularly of the latter. It would be required to decide whether the alcohol should be determined from the gravity of the spirits distilled from the beer; by the increased gravity of the beer when its alcohol is evaporated off; by the boiling point of the beer, which is lower the larger the proportion of alcohol present; or by the refracting power of the beer upon light—various methods recommended for the valuation of the spirits in beer.

Original gravities so deduced, however, are found to be useless, being in error and always under the truth, to an extent which has not hitherto been at all accounted for. The theory of brewing, upon a close examination of the process, proves to be less simple than is implied in the preceding assumption; and other changes appear to occur in worts, simultaneously with the formation of alcohol, which would require to be allowed for before original gravities could be rightly estimated. It was found necessary to study the gravity in solution of each by itself, of the principal chemical substances which are found in fermented liquids. These individual gravities defined the possible range of variation in original gravity, and they brought out clearly for the first time the nature of the agencies which chiefly affect the result.

The use of cane-sugar is now permitted in breweries, and the solution of sugar may be studied first as the wort of simplest composition. The tables of the specific gravity of sugar solutions, con-

structed by Mr. Bate, have been verified, and are considered entirely trustworthy. The numbers in the first and third columns of Table I., which follows, are, however, from new observations. It is to be remarked that these numbers have all reference to weights, and not to measures. A solution of cane-sugar, which contains 25 grains of sugar in 1000 grains of the fluid, has a specific gravity of 1010·1, referred to the gravity of pure water taken as 1000; a solution of 50 grains of cane sugar in 1000 grains of the fluid, a specific gravity of 1020·2, and so on. The proportion of carbon contained in the sugar is expressed in the second column; the numbers being obtained from the calculation that 171 parts by weight of cane-sugar ($C_{12} H_{11} O_{11}$) consist of 72 parts of carbon, 11 parts of hydrogen, and 88 parts of oxygen; or of 72 parts of carbon combined with 99 parts of the elements of water. It is useful to keep thus in view the proportion of carbon in sugar solutions, as that element is not involved in several of the changes which precede or accompany the principal change which sugar undergoes during fermentation, and which changes only affect the proportion of the oxygen and hydrogen, or elements of water, combined with the carbon. The proportion of oxygen and hydrogen in the altered sugar increases or diminishes during the changes referred to; but the carbon remains constant, and affords, therefore, a fixed term in the comparison of different solutions.

TABLE I.

SPECIFIC GRAVITY OF SOLUTIONS OF CANE-SUGAR IN WATER.

Cane-Sugar, in 1000 parts by weight.	Carbon in 1000 parts by weight.	Specific Gravity.
25	10·53	1010·1
50	21·05	1020·2
75	31·58	1030·2
100	42·10	1040·6
125	52·63	1051
150	63·16	1061·8
175	73·68	1072·9
200	84·21	1083·8
225	94·73	1095·2
250	105·26	1106·7

When yeast is added to the solution of cane-sugar in water, or to any other saccharine solution, and fermentation commenced, the specific gravity is observed to fall, owing to the escape of carbonic acid gas, and the formation of alcohol, which is specifically lighter than water; 171 grains of sugar, together with 9 grains of water, being converted into 92 grains of alcohol and 88 grains of carbonic acid ($C_{12} H_{11} O_{11} + HO = 2 C_4 H_6 O_2 + 4 CO_2$). But if the process of fer-

mentation be closely watched, the fall of gravity in cane-sugar will be found to be preceded by a decided increase of gravity. Solutions were observed to rise from 1055 to 1058, or 3 degrees of gravity, within an hour after the addition of the yeast, the last being in the usual proportion for fermentation. When the yeast was mixed in minute quantity only, such as $\frac{1}{300}$ of the weight of the sugar, the gravity of the sugar solution rose gradually in four days from 1055 to 1057·91, or also nearly 3 degrees; with no appearance, at the same time, of fermentation or of any other change in the solution. This remarkable increase of density is owing to an alteration which takes place in the constitution of the cane-sugar, which combines with the elements of water and becomes starch-sugar, a change which had been already proved by H. Rose and by Dubrunfaut, to precede the vinous fermentation of cane-sugar. The same conversion of cane-sugar into starch-sugar, with increase of specific gravity, may be shown by means of acids as well as of yeast. A solution of 1000 parts of cane-sugar in water, having the specific gravity 1054·64, became with 1 part of crystallised oxalic acid added to it 1054·7; and being afterwards heated for twenty-three hours to a temperature not exceeding 128° Fahr., it was found (when cooled) to have attained a gravity of 1057·63—an increase again of nearly 3 degrees of gravity.

In the table of starch-sugar, which follows, the influence of this conversion upon specific gravity is shown by placing together the gravities of cane-sugar and of the starch-sugar into which it is convertible, and which therefore contain equal quantities of carbon.

TABLE II.

COMPARISON OF THE SPECIFIC GRAVITIES OF SOLUTIONS OF CANE-SUGAR AND STARCH-SUGAR CONTAINING EQUAL QUANTITIES OF CARBON.

Cane-Sugar contained in 1000 parts by weight of Solution.	Specific gravity of solution of Cane-Sugar.	Specific gravity of solution of Starch-Sugar.
25	1010·1	1010·4
50	1020·2	1020·8
75	1030·2	1031·3
100	1040·6	1042·4
125	1051	1053·5
150	1061·8	1064·9
175	1072·9	1076
200	1083·8	1087·8
225	1095·2	1099·4
250	1106·7	1111·4

When yeast is added to a solution of starch-sugar, or of cane-sugar previously converted by means of oxalic acid, or by yeast itself, into starch-sugar, the rise of gravity described is no longer observed to precede fermentation. Hence the irregularity does not appear in an infusion of malt, which contains starch-sugar, and the attenuation of malt worts commences with the first action of the yeast, and advances without interruption till the fermentation is completed.

It is already evident from these statements, that the original gravity of a fermented liquid or beer must be different, according as it was derived from a wort of cane-sugar or of starch-sugar.

A comparison was next made of the specific gravities of solutions of pale and of brown malt with the solutions of the two pure sugars. The carbon determined by actual combustion in organic analysis, is the same in all the four solutions, of which the gravities are given in the same line, and is the proportion which exists in 25, 50, 75, &c., parts of cane-sugar, as in Table I.

TABLE III.

SPECIFIC GRAVITY OF SOLUTIONS OF PALE MALT, BROWN MALT, AND STARCH-SUGAR, CONTAINING EQUAL QUANTITIES OF CARBON.

Solution of Pale Malt.	Solution of Brown Malt.	Solution of Starch-Sugar.	Parts of Cane-Sugar corresponding in 1000 parts by weight of Solution.
1010·0	1010·0	1010·4	25
1020·3	1020·2	1020·8	50
1030·6	1030·6	1031·3	75
1041·2	1041·2	1042·4	100
1052·1	1052·0	1053·5	125
1063·0	1062·9	1064·9	150
1074·2	1074·0	1076·0	175
1085·5	1085·5	1087·8	200
1097·2	1097·2	1099·4	225
1109·0	1109·0	1111·4	250

It is interesting to observe how closely the gravities of the pale and brown malt agree together through the whole range of the Table. The gravities are often identical, and in no case differ more than 0·2 degree. This indicates a greater uniformity of density in the worts of different varieties of malt than could have been anticipated, and it gives a character of constancy to the density of malt wort, which is highly satisfactory.

The density of the malt worts also approaches that of the pure starch-sugar, but is always a little less by about 1 degree of gravity

in 35. Malt wort appears, indeed, intermediate between the two pure sugars. We have, for instance, solutions containing an equal quantity of carbon, which exhibit the following gravities :

Cane-Sugar	.	.	.	1072·9
Pale Malt	.	.	.	1074·2
Starch-Sugar	.	.	.	1076·0

Now, if the whole carbon of malt wort were present in the form of starch-sugar, the gravity of the wort should somewhat exceed that of the pure starch-sugar solution, as a small proportion of alkaline and earthy salts exist in the malt infusion, and must add to its gravity. The carbon present in the small quantity of albumen of the malt could not affect the result materially in either way.

But there are two other substances related to sugar, of which the interference in malt infusions may be anticipated, namely, Dextrin, or the gum of starch, and Caramel. These are both forms of the sugar principle, the transition from the one condition to the other depending upon the fixation of the elements of water in the substance, or the liberation of a proportion of water. Observations were in consequence made of the gravities of pure solutions of dextrin prepared from starch, and of caramel produced by the proper application of heat to sugar.

TABLE IV.

SPECIFIC GRAVITIES OF SOLUTIONS OF CARAMEL, DEXTRIN, AND STARCH-SUGAR, CONTAINING EQUAL QUANTITIES OF CARBON.

Solution of Caramel.	Solution of Dextrin.	Solution of Starch-Sugar.	Parts of Cane-Sugar corresponding in 1000 parts by weight of Solution.
1008·7	1009·7	1010·4	25
1017·3	1019·3	1020·8	50
1026·2	1028·8	1031·3	75
1034·9	1038·3	1042·4	100
1043·8	1047·9	1053·5	125
1052·8	1057·3	1064·9	150
1062·3	1066·9	1076·0	175
1071·8	1067·6	1087·8	200
1081·3	1086·3	1099·4	225
1091·0	1095·8	1111·4	250

It will be observed that the gravities of both caramel and dextrin are considerably less than those of starch-sugar, and that consequently

the presence of either of these substances, taking the place of starch-sugar in a malt infusion, must lower the specific gravity of the latter. The following solutions of the three different substances, containing the same quantity of carbon, appear by the Table to have different gravities :

Starch-Sugar	.	.	.	1076
Dextrin	.	.	.	1066.9
Caramel	.	.	.	1062.3

The solution of cane-sugar containing the same quantity of carbon, has the specific gravity of 1072.9, and contains 175 grains of cane-sugar in 1000 grains of the solution, or 17.5 per cent of cane-sugar. It follows that this proportion of the saccharine principle may present itself with specific gravities varying from 1076 to 1062.3, in the different forms which it can assume. A certain quantity of dextrin generally exists in the wort of malt, which may be thrown down by alcohol. Dextrin was prepared in a pure state from this source. Its presence is, of course, due to the incomplete saccharization of the starch of malt in the process of mashing.

With regard to the existence of the other substance, caramel, in malt infusions, the extreme facility with which starch-sugar is altered by heat, would lead us to look for the production of caramel in the kiln-drying of malt, particularly of brown malt. Its production is indicated by the dark colour of the infusion of the highly dried malt. Of the 3 or 4 per cent of black malt used for colouring porter, the whole soluble portion appears also to be caramel. It may be further added, that the use of caramel prepared from sugar, as a colouring ingredient of porter, is now permitted in breweries.

A substance resembling caramel in some of its properties is developed in fermented liquids in another way. The saccharine matter of the wort is never wholly converted into carbonic acid and alcohol in the most favourable circumstances, a portion of solid matter always remaining, which is no further fermentable even after the alcohol is distilled off and fresh yeast applied. This residuary matter is generally spoken of as a gummy substance, but when obtained by the fermentation of pure sugar, it partakes more of the characters of caramel, or of glucic acid, particularly in the low gravity of its solution in water. Of pure cane-sugar fermented, 4.1, 3.72, and 3.7 per cent was converted into this substance in three fermentations, in which one and a half, three, and six measures of yeast were employed to one hundred measures of solution, containing one-seventh of its weight of sugar.

The extractive substance resembling caramel was obtained in the form of a dark brown syrup, by evaporating the liquid after fer-

mentation had entirely ceased. It reddened litmus-paper, contained lactic acid, and was distinctly sour and slightly bitter to the taste. That this residuary substance contained no longer any starch-sugar, appeared from the fact, that on mixing its diluted solution with caustic potash, and heating it, the colour was not sensibly darkened. It was no longer fermentable by yeast, and it did not become so (like dextrin) after being boiled with sulphuric acid. It resembled caramel in giving with sulphate of copper and caustic potash in excess a transparent blue solution, from which suboxide of copper was thrown down on the application of heat. It is precipitated by baryta-water, and gives with subacetate of lead a brown precipitate, which, however, is more voluminous and paler in colour than the precipitate from pure caramel. Neutral acetate of lead precipitates a portion only of this substance, proving that it is not a single principle, but a mixture of two or more substances.

A solution of it compared with that of caramel, obtained by heating cane-sugar to 410° Fahr., and both containing the same proportions of carbon, gave very similar densities.

TABLE V.

SPECIFIC GRAVITIES OF SOLUTIONS OF CARAMEL FROM CANE-SUGAR, AND OF THE EXTRACTIVE SUBSTANCE FROM THE FERMENTATION OF SUGAR, CONTAINING EQUAL QUANTITIES OF CARBON.

Solution of Caramel.	Solution of Extractive Substance.	Parts of Cane-Sugar corresponding, in 1000 parts by weight of Solution.
1008.7	1008.9	25
1017.3	1017.8	50
1026.2	1026.5	75
1034.9	1035.5	100
1043.8	1044.7	125
1052.8	1053.9	150
1062.3	1063.0	175
1071.8	1072.7	200
1081.3	1082.3	225

This extractive substance appears to interfere more than dextrin in giving lightness or apparent attenuation to fermented worts, without a corresponding production of alcohol. Its effect becomes the more sensible the more nearly the worts are exhausted by fermentation. It is produced in the fermentation of both kinds of sugar and also of malt. There appears to be a certain uniformity in the proportion of saccharine matter which undergoes this change in every brewing,

judging from the correspondence of different beers in their gravities, at the same stage of fermentation, which shall afterwards be exhibited. It causes a marked irregularity in the progression of the gravities when the fermentation is carried to an extreme, as it is in distilleries; but in brewing beer the fermentation is always arrested at a point in its progress too early to allow the effect of the extractive substance upon the gravity to become very conspicuous.

The indication by gravity of the extractive substance is so much lower than that of starch-sugar, that the former substance only indicates about five-sixths of the saccharine principle which has given rise to it. Hence it is that original gravities cannot be calculated on the assumption that the solid matter in beer is sugar, or a substance having the same gravity as sugar.

In the maturation of beer by time, an increase of attenuation is observed, which is no doubt chiefly due to the slow continuation of the vinous fermentation, with the disappearance of sugar and formation of alcohol; but there is some reason to believe that the attenuation is not entirely due to that cause. Part of the loss of gravity appears to be occasioned by the change in condition of the saccharine principle from that of starch-sugar to the condition of the extractive substance, a change which involves a loss of specific gravity without a corresponding production of alcohol.

Another constituent of malt wort, which should not be omitted, is the soluble azotized or albuminous principle derived from the grain. The nitrogen was determined in a strong wort of pale malt with hops, of the specific gravity 1088, and containing about 21 per cent of solid matter. It amounted to 0.217 per cent. of the wort, and may be considered as representing 3.43 per cent of albumen. In the same wort, after being fully fermented, the nitrogen was found to amount to 0.134 per cent, equivalent to 2.11 per cent of albumen. The loss observed of nitrogen and albumen may be considered as principally due to the production and growth of yeast, which is an insoluble matter, at the cost of the soluble albuminous matter. Solutions of egg-albumen in water, containing 3.43 and 2.11 per cent respectively of that substance, were found to have the specific gravities of 1004.2 and 1003.1. Hence a loss of density has occurred during fermentation of 1.1 degree on a wort of 1088 original gravity, which can be referred to a change in the proportion of albuminous matter. It will be observed that the possible influence of this substance and of the greater or less production of yeast during fermentation, upon the gravity of beer, are restricted within narrow limits.

The mineral constituents of the same worts, consisting of soluble salts of the earths and alkalies, amounted before fermentation to 0.443 per cent, and after fermentation to 0.463 per cent. The

proportion of these substances may therefore be supposed to remain constant.

The process required for the determination of the original gravity of beer, must be easy of execution, and occupy little time. It is not proposed, in the examination of a sample, to separate by chemical analysis the several constituents which have been enumerated. In fact, we are practically limited to two experimental observations on the beer, in addition to the determination of its specific gravity.

One of these is the observation of the amount of solid or extractive matter still remaining after fermentation, which is always more considerable in beer than in the completely fermented wash of spirits. A known measure of the beer might be evaporated to dryness, and the solid residue weighed, but this would be a troublesome operation, and could not indeed be executed with great accuracy. The same object may be attained with even a more serviceable expression for the result, by measuring exactly a certain quantity of the beer, such as four fluid ounces, and boiling it down to somewhat less than half its bulk in an open vessel, such as a glass flask, so as to drive off the whole alcohol. The liquid when cool is made up to four fluid ounces, or the original measure of the beer, and the specific gravity of this liquid is observed. It has already been referred to as to the extract gravity of the beer, and represents a portion of the original gravity. Of a beer of which the history was known, the original gravity of the malt wort was 1121, or 121 degrees; the specific gravity of the beer itself before evaporation, 1043; and the extract gravity of the beer 1056·7, or 56·7 degrees.

The second observation which can be made with sufficient facility upon the beer, is the determination of the quantity of alcohol contained in it. This information may be obtained most directly by submitting a known measure of the beer to distillation, continuing the ebullition till all the alcohol is brought over, and taking care to condense the latter without loss. It is found in practice that four ounce-measures of the beer form a convenient quantity for the purpose. This quantity is accurately measured in a small glass flask, holding 1750 grains of water when filled up to a mark in the neck. The mouth of the small retort containing the beer is adapted to one end of a glass tube-condenser, the other end being bent and drawn out for the purpose of delivering the condensed liquid into the small flask previously used for measuring the beer. The spirituous distillate should then be made up with pure water to the original bulk of the beer, and the specific gravity of the last liquid be observed by the weighing bottle, or by a delicate hydrometer, at the temperature of 60° Fahr. The lower the gravity the larger will be the proportion of alcohol, the exact amount of which may be learned by reference to the proper tables of the gravity of spirits. The spirit-gravity of the

beer already referred to, proved to be 985.95; or it was 14.05 degrees of gravity less than 1000 or water. The "spirit-indication" of the beer was therefore 14.05 degrees; and the extract gravity of the same beer 56.7 degrees.

The spirit-indication and extract gravity of any beer being given, do we possess data sufficient to enable us to determine with certainty the original gravity? It has already been made evident that these data do not supply all the factors necessary for reaching the required number by calculation.

The formation of the extractive matter, which chiefly disturbs the original gravity, increases with the progress of the fermentation; that is, with the proportion of alcohol in the fermenting liquor. But we cannot predicate from theory any relation which the formation of one of these substances should bear to the formation of the other, and are unable, therefore, to say beforehand that because so much sugar has been converted into alcohol in the fermentation, therefore so much sugar has also been converted into the extractive substance. That a uniform, or nearly uniform relation, however, is preserved in the formation of the spirits and extractive substance, in beer-brewing, appears to be established by the observations which follow. Such a uniformity in the results of the vinous fermentation is an essential condition for the success of any method whatever of determining original gravities, at least within the range of circumstances which affect beer-brewing. Otherwise two fermented liquids of this class, which agree in giving both the same spirit-indication and the same extractive gravity, may have had different original gravities, and the solution of our problem becomes impossible.

The fermentation of liquids of known composition and original gravity, containing pure cane-sugar, pure starch-sugar, and the soluble matter of malt, the latter both with and without hops, was now repeated, and the wort examined in each fermentation at ten or twelve different stages of its progress, or after short periods of a few hours. The two required observations of the spirit-indication and extract gravity were made on every occasion, with certain additional observations which shall again be referred to.

The details of these and the numerous other fermentations referred to, were conducted, under our directions, by Mr. Adam Young and Mr. C. B. Forsey (officers of Inland Revenue), lately of the Birkbeck Laboratory, to whom we have great pleasure in acknowledging our obligations for the valuable aid which a perfect acquaintance with the subject, and remarkable skill in experimenting, combined with the most untiring zeal, could supply.

The results of a particular fermentation of cane-sugar may be stated. Fifteen and a half pounds of refined sugar were dissolved in 10 gallons of water, making $10\frac{7}{8}$ gallons of solution, of which the

specific gravity was 1055·3 at 60°; and after adding three fluid pounds of fresh porter yeast, the specific gravity was 1055·95. The original gravity may be taken as 1055·3 (55·3 degrees).

FERMENTATION OF SUGAR-WORT OF ORIGINAL GRAVITY 1055·3.

I. Number of Observation.	II. Period of Fermentation.		III. Degrees of Spirit Indication.	IV. Degrees of Extract Gravity.	V. D egree of Extract Gravity <i>lost</i> .
	Days.	Hours.			
1	0	0	0	55·30	0·
2	0	6	1·59	52·12	3·18
3	0	12	2·57	47·82	7·48
4	0	19	3·60	43·62	11·68
5	0	23	4·33	40·13	15·17
6	1	5	5·31	35·50	19·80
7	1	12	6·26	31·39	23·91
8	1	19	7·12	27·63	27·67
9	2	11	8·59	20·26	35·04
10	3	11	9·87	13·40	41·90
11	5	12	10·97	7·60	47·70
12	6	12	11·27	4·15	51·15

Columns III. and v. respectively exhibit the spirit which has been produced, and the solid matter which has disappeared; the first in the form of the gravity of the spirit, expressed by the number of degrees it is lighter than water, or under 1000, and the second by the fall in gravity of the solution of the solid matter remaining below the original gravity 1055·3. This last value will be spoken of as “degrees of gravity lost;” it is always obtained by subtracting the extract gravity (column iv.) from the known original gravity. To discover whether the progress of fermentation has the regularity ascribed to it, it was necessary to observe whether the same relation always holds between the columns of “degrees of spirit-indication” and “degrees of gravity lost.” It was useful, with this view, to find what degrees lost corresponded to whole numbers of degrees of spirit-indication. This can be done safely from the preceding Table, by interpolation, where the numbers observed follow each other so closely. The corresponding degrees of spirit-indication and of gravity lost, as they appear in this experiment upon the fermentation of sugar, are as follows:

FERMENTATION OF SUGAR-WORT, OF ORIGINAL GRAVITY 1055.3.

Degrees of Spirit-Indication.	Degrees of Extract Gravity lost.
1	1.71
2	4.74
3	9.26
4	13.48
5	18.30
6	22.54
7	27.01
8	31.87
9	37.12
10	42.55
11	47.88

In two other fermentations of cane-sugar, the degrees of gravity lost, found to correspond to the degrees of spirit-indication, never differed from the numbers of the preceding experiment, or from one another, more than 0.9 degree of gravity lost. This is a sufficiently close approximation.

FERMENTATION OF SUGAR-WORT OF ORIGINAL GRAVITY 1054.7, A; AND OF SUGAR-WORT OF ORIGINAL GRAVITY 1028.8, B.

Degrees of Spirit-Indication.	Degrees of Extract Gravity lost.	
	A.	B.
1	2.01	1.94
2	5.15	4.84
3	9.22	9.90
4	13.95	14.10
5	18.09	18.31
6	23.16	22.61
7	27.05	27.51
8	32.26	
9	37.40	
10	42.16	
11	47.56	

The observations of the three experiments were combined in the following Table, which exhibits the mean results. Besides the degrees
VOL. V.—NO. XIX.

of gravity lost corresponding to whole degrees of spirit-indication, the degrees of gravity lost corresponding to tenths of a degree of spirit-indication are added from calculation.

TABLE VI.—CANE-SUGAR.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST.

Degrees of Spirit-Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·2	·3	·5	·7	·9	1·0	1·2	1·4	1·6
1	1·9	2·1	2·4	2·7	3·0	3·3	3·6	3·9	4·2	4·6
2	5·0	5·4	5·8	6·2	6·6	7·0	7·5	8·0	8·5	9·0
3	9·5	9·9	10·3	10·7	11·2	11·6	12·0	12·4	12·8	13·3
4	13·8	14·2	14·6	15·0	15·5	15·9	16·3	16·7	17·2	17·7
5	18·3	18·7	19·1	19·5	19·9	20·3	20·8	21·2	21·7	22·2
6	22·7	23·1	23·5	23·9	24·4	24·7	25·2	25·6	26·1	26·6
7	27·1	27·6	28·1	28·6	29·1	29·6	30·0	30·5	31·0	31·5
8	32·0	32·5	33·0	33·5	34·0	34·5	35·0	35·5	36·0	36·6
9	37·2	37·7	38·2	38·7	39·2	39·7	40·3	40·8	41·3	41·8
10	42·4	42·9	43·4	44·0	44·5	45·0	45·6	46·1	46·6	47·2
11	47·7									

It is seen from this Table that for 5 degrees of spirit-indication, the corresponding degrees of gravity lost are 18·3 degrees. For 5·9 degrees of spirit-indication, the corresponding degrees of gravity lost are 22·2 degrees.

This Table is capable of a valuable application, for the sake of which it was constructed. By means of it, the unknown original gravity of a fermented liquid, or beer, from cane-sugar, may be discovered, provided the spirit-indication and extract gravity of the beer are observed. Opposite to the spirit-indication of the beer in the Table, we find the corresponding degrees of gravity lost, which last, added to the extract gravity of the beer, gives its original gravity.

Suppose the sugar-beer exhibited an extract gravity of 7·9 degrees (1007·9), and spirit-indication of 11 degrees. The latter marks, according to the Table, 47·7 degrees of gravity lost, which added to the observed extract gravity, 7·9 degrees, gives 55·6 degrees of original gravity for the beer (1055·6).

The table which follows was constructed in the same manner for starch-sugar, from two fermentations of the pure substance, and gives the means of calculating the original gravity of liquids fermented from starch-sugar, when the spirit-indication and extract gravity of the beer are known from experiment. The extreme deviation between the two series of observations was 0·8 degree of gravity lost.

TABLE VII.—STARCH-SUGAR.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST.

Degrees of Spirit-Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·6	·9	1·2	1·5	1·8	2·1	2·4	2·7
1	3·0	3·3	3·7	4·0	4·4	5·0	5·0	5·4	5·8	6·2
2	6·6	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·3
3	10·7	11·1	11·5	12·0	12·4	12·9	13·3	13·7	14·1	14·5
4	15·0	15·4	15·9	16·4	16·8	17·3	17·7	18·2	18·7	19·2
5	19·7	20·1	20·6	21·0	21·5	22·0	22·5	23·0	23·5	24·0
6	24·5	25·0	25·4	25·9	26·4	26·8	27·3	27·8	28·3	28·8
7	29·3	29·7	30·2	30·7	31·1	31·6	32·0	32·5	33·0	33·5
8	34·0	34·5	35·0	35·5	36·0	36·5	37·0	37·5	38·0	38·5
9	39·0	39·5	40·1	40·6	41·1	41·7	42·2	42·8	43·3	43·9
10	44·5	45·1	45·8	46·5						

The numbers will be observed to differ from those of the preceding Table for cane-sugar, and to be all greater, the differences increasing pretty uniformly with the higher degrees of spirit-indication. The corresponding numbers for 10 degrees of spirit-indication are 42·4 in cane-sugar, and 44·5 in starch-sugar, or a difference of 2·1 degrees of gravity lost. By this difference the original gravity of the beer of starch-sugar is increased over that of cane-sugar, as should be the case; the specific gravity of starch-sugar being always higher than that of cane-sugar containing an equal weight of carbon, and capable of yielding an equal quantity of spirits. (See Table II.)

The three Tables for malt worts of different kinds which follow, will be found to agree well with each other, and also to accord closely with the preceding Table for pure starch-sugar worts.

TABLE VIII.—PALE MALT WITHOUT HOPS.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST.

Degrees of Spirit-Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·6	·9	1·2	1·5	1·8	2·2	2·5	2·8
1	3·2	3·6	3·9	4·3	4·6	5·0	5·4	5·8	6·2	6·6
2	7·0	7·4	7·8	8·2	8·6	8·9	9·4	9·8	10·3	10·7
3	11·2	11·6	12·1	12·6	13·0	13·4	13·8	14·2	14·6	15·0
4	15·5	15·9	16·4	16·9	17·3	17·7	18·1	18·6	19·1	19·5
5	20·0	20·5	20·9	21·3	21·8	22·2	22·7	23·1	23·6	24·1
6	24·6	25·0	25·5	25·9	26·3	26·8	27·3	27·8	28·3	28·8
7	29·3	29·7	30·2	30·7	31·2	31·7	32·2	32·7	33·2	33·7
8	34·2	34·7	35·2	35·7	36·3	36·9	37·5	38·1	38·6	39·1
9	39·5	40·0	40·5	41·0						

The results given are the means of the observations of two fermentations of pale malt without hops, which accorded throughout within 1 degree of gravity.

TABLE IX.—PALE MALT WITH HOPS.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST.

Degrees of Spirit-Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·2	·5	·7	1·0	1·3	1·6	1·9	2·2	2·5
1	2·8	3·1	3·4	3·7	4·0	4·4	4·8	5·2	5·5	5·9
2	6·3	6·7	7·1	7·5	8·0	8·4	8·8	9·2	9·6	10·0
3	10·5	10·9	11·3	11·8	12·2	12·7	13·1	13·6	14·0	14·5
4	15·0	15·4	15·8	16·3	16·7	17·1	17·6	18·0	18·5	19·0
5	19·5	19·9	20·4	20·9	21·3	21·7	22·2	22·7	23·1	23·5
6	23·9	24·4	24·8	25·3	25·7	26·2	26·6	27·0	27·4	27·9
7	28·4	28·9	29·4	29·9	30·4	30·8	31·2	31·7	32·2	32·7
8	33·2									

The results are the means of the observations of two fermentations of pale malt with hops, which corresponded throughout within 0·49 degree of gravity lost.

TABLE X.—BROWN AND PALE MALT.—EQUAL WEIGHTS.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST.

Degrees of Spirit-Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·6	·9	1·2	1·5	1·8	2·1	2·4	2·8
1	3·1	3·4	3·7	4·0	4·3	4·7	5·1	5·5	5·9	6·2
2	6·6	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
3	10·5	10·8	11·3	11·7	12·2	12·6	13·0	13·5	13·9	14·0
4	14·8	15·2	15·6	16·1	16·5	17·0	17·4	17·8	18·2	18·6
5	19·0	19·4	19·8	20·2	20·6	21·0	21·5	22·0	22·5	23·0
6	23·5	23·9	24·4	24·9	25·4	25·9	26·4	26·9	27·4	27·9
7	28·2	28·7	29·2	29·8	30·3	30·8	31·3	31·9	32·4	32·9
8	33·5	34·2	34·9	35·8						

This table was derived from a single experiment. No observation could be made upon brown malt alone, as it could not be fully fermented without a considerable admixture of pale malt.

For comparison, the numbers corresponding to the integral degrees of spirit-indication of the five different Tables are placed together in the following Table :

TABLE XI.—VARIOUS WORTS.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST.

Degrees of Spirit- Indication.	I. Cane- Sugar.	II. Starch- Sugar.	III. Pale Malt.	IV. Pale Malt with Hops.	V. Brown and Pale Malt.	VI. Mean of ii, iii, iv, & v.
1	1.9	3.0	3.2	2.8	3.1	3.0
2	5.0	6.6	7.0	6.3	6.6	6.6
3	9.5	10.7	11.2	10.5	10.5	10.7
4	13.8	15.0	15.5	15.0	14.8	15.1
5	18.3	19.7	20.0	19.5	19.0	19.5
6	22.7	24.5	24.6	23.9	23.5	24.1
7	27.1	29.3	29.3	28.4	28.2	28.8
8	32.0	34.0	34.2	33.2	33.5	33.9
9	37.2	39.0	39.5	—	—	39.25
10	42.4	44.5	—	—	—	44.5
11	47.7	—	—	—	—	—

The first point which excites attention is the general similarity of all the four columns which refer to liquids containing the same fermentable substance, starch-sugar. In comparing together column II. and III., those of starch-sugar itself and pale malt without hops, the greatest difference observed between any two corresponding numbers is 0.5, or half a degree of gravity. The numbers of the two columns are the same at one point, but at all other places the starch-sugar column is slightly exceeded by the pale malt column. It thus appears that the phenomena of the fermentation of pale malt are closely represented by a solution of pure starch-sugar. The other substances besides sugar, of which small quantities are known to be present in malt, appear therefore not to be subjected to any change during the fermentation of the wort, which materially affects the gravity of the latter. The addition of hops to the malt has a slight effect in lowering the gravity numbers, as seen in column IV., to the extent at one point of 1 degree of gravity. Brown malt appears to act in the same direction as hops upon the progression of gravities (column V.) but with less effect, although the quantity of the former was made as large in the experiment as was consistent with fermentation, and much greater than is ever employed by the brewer. The general mean of these four liquids, all containing starch-sugar, appears in column VI.

The highest degree of original gravity which the sugar-solutions and malt infusions of the preceding Tables possessed before fermentation, was about 1057, but it was desirable to extend the observations to worts of higher gravities. Pale malt worts with hops, which, representing beer, are of most interest, were fermented: they had in two experiments the original gravity 1087.9, and in one experiment 1121, and were frequently examined at different stages, as before, till all fermentation ceased. The three experiments gave

numbers which did not diverge anywhere during their common range more than 0·7 degree of gravity, and at the same time were in harmony with the earlier experiments on pale malt with hops (Table IX.) The mean of the new experiments gave for six degrees of spirit-indication, 24·0 degrees of gravity lost, instead of 23·9 degrees, as in Table IX.; and for 7 degrees of spirit-indication, 28·7 degrees of gravity lost, in the place of 28·4, as in Table IX.

TABLE XII.—MALT-WORT OF HIGH ORIGINAL GRAVITY WITH HOPS.
DEGREES OF SPIRIT-INDICATION WITH DEGREES OF GRAVITY LOST.

Degrees of Spirit- Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0										
1										
2										
3										
4										
5	—	—	—	—	—	—	22·1	22·5	23·0	23·5
6	24·0	24·4	24·9	25·3	25·8	26·2	26·7	27·2	27·7	28·2
7	28·7	29·2	29·6	30·1	30·6	31·1	31·6	32·1	32·6	33·1
8	33·6	34·1	34·7	35·2	35·7	36·2	36·7	37·2	37·7	38·2
9	38·7	39·2	39·8	40·3	40·8	41·3	41·8	42·3	42·8	43·3
10	43·8	44·3	44·9	45·4	45·9	46·4	47·0	47·5	48·0	48·5
11	49·0	49·6	50·1	50·6	51·2	51·7	52·2	52·7	53·3	53·8
12	54·3	54·9	55·4	55·9	56·4	56·9	57·4	57·9	58·4	58·9
13	59·4	60·0	60·5	61·1	61·6	62·2	62·7	63·3	63·8	64·3
14	64·8	65·4	65·9	66·5	67·1	67·6	68·2	68·7	69·3	69·9
15	70·5									

This last Table, combined with Table XI., exhibits the relation between the spirits obtained by distillation from beer, and the degrees of gravity which the original wort loses in producing the spirits, through a range of gravity in the wort, which ascends from 1000 to 1121. It is given in a complete form as Table A, at the end of the Report.

By means of Table A the original gravity of a specimen of beer may therefore be calculated back, and ascertained from the two data which have been specified, namely (1), the degree of spirit-indication which the spirits contained in the beer exhibit, when made up with water to the same measure as the original beer; and (2) the extract gravity of the beer, or the specific gravity of the beer deprived of its spirit, and made up to its original volume with water. A specimen of beer when examined gave the following data :

Spirit-indication	.	.	.	9·9
Extract gravity	.	.	.	1044·7

By Table A, 9·9 degrees of spirit-indication represent 43·7 degrees of gravity lost; which, added to 1044·7, the extract gravity of the same beer, make up 1088·4 degrees, the original gravity of the beer.

The two experimental data required to furnish means of determining the original gravity of beer, by the process already described, are obtained with great precision when proper care is taken. One of these data, however, namely, the spirit-indication of the beer, involves the distillation of the beer, and the collection of the whole alcohol without loss, a delicate process, which it has been attempted to supersede by operations of less difficulty and nicety. One of these operations, long practised by the German brewers, has been examined and recommended by Balling, and has also been investigated by Messrs. Dobson and Phillips, under whose notice it appears to have been first brought as a method which Mr. Stevenson, of Edinburgh, had suggested and attempted to carry out.

The object is still to obtain the spirit-indication of the beer. The specific gravity of the beer is first observed by means of the hydrometer or weighing-bottle. The extract gravity of the beer is next observed as in the former method; but the beer for this purpose may be boiled in an open glass flask till the spirits are gone, as the new process does not require the spirits to be collected. The spiritless liquid remaining is then made up to the original volume of the beer as before. By losing its spirits, the beer of course always increases in gravity, and the more so the richer in alcohol the beer has been. The difference between the two gravities is the new spirit-indication, and is obtained by subtracting the beer gravity from the extract gravity, which last is always the higher number.

The data in a particular beer were as follows:—

Extract gravity	.	.	.	.	1044·7
Beer gravity	.	.	.	.	1035·1
Spirit-indication	.	.	.	.	9·6 degrees.

Now the same beer gave by distillation, or the former method, a spirit-indication of 9·9 degrees. The new spirit-indication by evaporation is, therefore, less by 0·3 degree than the old indication by distillation. The means were obtained of comparing the two indications given by the same fermented wort or beer in several hundred cases, by adopting the practice of boiling the beer in a retort, instead of an open flask or basin, and collecting the alcohol at the same time. The evaporation uniformly indicated a quantity of spirits in the beer nearly the same as was obtained by distillation, but always sensibly less, as in the preceding instance. These experiments being made upon fermented liquids of known original gravity, the relation could always be observed between the new spirit-indication and the degrees of specific gravity lost by the beer. Tables of the degrees of spirit-indication, with their corresponding degrees of gravity lost, were thus constructed, exactly in the same manner as the Tables which precede; and these new Tables may be applied in the same way to ascertain

the original gravity of any specimen of beer. Having found the degrees of spirit-indication of the beer by evaporation, the corresponding degrees of gravity lost are taken from the Table, and adding these degrees to the extract gravity of the beer, also observed, the original gravity is found. Thus the spirit-indication (by the evaporation method) of the beer lately referred to, was 9·6 degrees, which mark 43 degrees of gravity lost in the new Tables. Adding these to 1044·7, the extract gravity of the same beer, 1087·7 is obtained as the original gravity of the beer.

As the numbers of the second set of Tables belonging to the evaporation process, are derived from the same fermentations of cane-sugar starch-sugar, and malt in different conditions, as supplied the first series of Tables, they give the means of forming a strict comparison between the spirit-indications obtained by the two processes.

The want of coincidence between the two sets of Tables requires explanation. The same degrees of gravity lost give less spirit, or, in other words, the same spirits or degrees of spirit-indication always give more degrees of gravity lost in the Evaporation Tables, principally from this circumstance. When alcohol is added to pure water the density of the latter undergoes a certain diminution. By an addition of eight per cent by weight of alcohol the density of water is reduced from 1000 to 986·7, which is a loss of gravity of 13·3 degrees. But eight per cent of alcohol in the same volume as before of water containing ten per cent. of cane-sugar, occasions a loss of gravity of only 12·92 degrees (a fall from 1036·47 to 1023·55). The degrees of spirit-indication obtained are, therefore, less from the same absolute quantity of spirit in the sugar solution than in pure water. Now the sugar solution containing alcohol represents the beer, and gives the loss of gravity which the beer sustains by evaporation. On the other hand, the first mixture of pure water and alcohol represents the dilute spirits obtained from the same beer by distillation. The results here are :

Degrees of spirit-indication 13·30, by distillation.

“ “ “ 12·92, by evaporation.

Difference . . . 0·38

It thus appears that alcohol reduces the gravity of a solution of sugar, or we may suppose infusion of malt, not quite so much, by a small quantity, as it reduces the gravity of water. It has hitherto been believed that alcohol has the same effect upon the density of saccharine solutions as upon water, in which case the spirit-indications obtained from beer by the evaporation and distillation methods should necessarily be the same. But it appears from the following series of experiments on the subject, that a sensibly greater condensation always occurs when spirits are mixed with saccharine solutions than with water.

TABLE XIII.—SUGAR DISSOLVED IN SPIRITS,
COMPARED WITH SUGAR DISSOLVED IN EQUAL VOLUMES OF WATER.

Alcohol, in 100 parts of Solvent.	Sugar, added to 100 parts of Solvent.	Specific gravity of Solvent.	Specific gravity of Solution.	Spirit-Indi- cation in Water.	Spirit-Indi- cation in Solution of Sugar.
0	5	1000	1018.83		
2	5	996.35	1015.19	3.65	3.64
4	5	992.80	1011.74	7.20	7.09
6	5	989.63	1008.52	10.37	10.31
8	5	986.76	1005.70	13.24	13.13
10	5	983.91	1002.91	16.09	15.92
12	5	981.23	1000.35	18.77	18.48
0	10	1000	1036.47		
2	10	996.35	1032.90	3.65	3.57
4	10	992.80	1029.49	7.20	6.98
6	10	989.63	1026.31	10.37	10.16
8	10	986.76	1023.56	13.24	12.91
10	10	983.91	1020.77	16.09	15.70
12	10	981.23	1018.23	18.77	18.24
0	15	1000	1053		
2	15	996.35	1049.54	3.65	3.46
4	15	992.80	1046.24	7.20	6.76
6	15	989.63	1043.20	10.37	9.80
8	15	986.76	1040.42	13.24	12.58
10	15	983.91	1037.63	16.09	15.37
12	15	981.23	1035.06	18.77	17.94
0	20	1000	1068.62		
2	20	996.35	1065.26	3.65	3.36
4	20	992.80	1061.99	7.20	6.63
6	20	989.63	1059.06	10.37	9.56
8	20	986.76	1056.31	13.24	12.31
10	20	983.91	1053.52	16.09	15.10
12	20	981.23	1050.82	18.77	17.80

This increased condensation, although small in amount, will be found quite sufficient to account for the difference, amounting to about 1.3 degrees of gravity in the higher numbers, which holds between the gravities lost, corresponding to the same degrees of spirit-indication in the two series of Tables. To obtain the correct original gravity of beer, it is therefore necessary to make use of the proper Table, according as the spirit-indication of the beer has been obtained by the distillation or by the evaporation method. The degrees of gravity lost thus found, are added to the extract gravity, which is the same in both modes of examination.

Although the evaporation process is the easiest in practice, yet it does not appear to admit of the same degree of precision as the distillation process. In two experiments made upon the same beer, a difference of 0.4 or 0.5 degree of original gravity is not unusual with the evaporation, instead of the coincidence almost perfect, which holds

in the repetition of the distillation. It is believed that the imperfect result of the evaporation depends chiefly upon the difficulty of observing with accuracy the specific gravity of a frothing liquid like beer, which is one of the data. The carbonic acid in the beer can have little influence, otherwise, on the result, for it seldom constitutes more than one five-hundredth part of the whole weight of the beer. The gravity of the dissolved carbonic acid appears to exceed a little only that of water, so that although the former is driven off entirely in the boiling, it is replaced afterwards by a liquid (water) of nearly equal density, when the extract gravity is observed. The carbonic acid therefore is reckoned as so much water in the beer.

The Tables of the mean results obtained from the various worts by the evaporation process are now subjoined.

TABLE XIV.—CANE-SUGAR.

DEGREES OF SPIRIT-INDICATION, WITH CORRESPONDING DEGREES OF GRAVITY
LOST.

Degrees of Spirit- Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·2	·4	·6	·8	1·0	1·2	1·4	1·7	2·0
1	2·3	2·6	3·0	3·3	3·7	4·0	4·4	4·7	5·0	5·4
2	5·8	6·1	6·5	6·9	7·3	7·7	8·1	8·5	8·9	9·4
3	9·9	10·4	10·8	11·3	11·7	12·2	12·6	13·1	13·6	14·0
4	14·4	14·8	15·3	15·7	16·2	16·6	17·0	17·4	17·8	18·2
5	18·7	19·1	19·6	20·0	20·4	20·9	21·4	21·9	22·4	22·9
6	23·4	23·8	24·3	24·8	25·2	25·7	26·1	26·6	27·1	27·6
7	28·1	28·5	29·0	29·5	29·9	30·4	30·8	31·3	31·8	32·3
8	32·8	33·3	33·8	34·3	34·8	35·3	35·8	36·3	36·8	37·3
9	37·8	38·3	38·8	39·3	39·8	40·3	40·8	41·3	41·8	42·3
10	42·8	43·3	43·9	44·4	45·0	45·6	46·1	46·7	47·3	47·9
11	48·5									

TABLE XV.—STARCH-SUGAR.

Degrees of Spirit- Indication	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·6	·9	1·2	1·5	1·8	2·2	2·5	2·9
1	3·2	3·6	4·0	4·3	4·7	5·1	5·5	5·9	6·3	6·7
2	7·1	7·5	7·9	8·4	8·8	9·2	9·6	10·0	10·4	10·8
3	11·3	11·7	12·1	12·6	13·0	13·5	13·9	14·3	14·7	15·1
4	15·6	16·0	16·5	16·9	17·4	17·8	18·3	18·7	19·1	19·5
5	20·0	20·4	20·9	21·3	21·8	22·2	22·7	23·2	23·7	24·2
6	24·7	25·1	25·6	26·1	26·6	27·1	27·6	28·1	28·6	29·1
7	29·7	30·0	30·5	31·0	31·5	32·0	32·5	33·0	33·5	34·0
8	34·4	34·9	35·5	36·0	36·5	37·1	37·6	38·1	38·6	39·1
9	39·6	40·2	40·7	41·2	41·7	42·3	42·8	43·3	43·8	44·3
10	44·8	45·3	45·9	46·4	47·0	47·5	48·0	48·6	49·1	49·6

TABLE XVI.—MALT WORT WITHOUT HOPS.

[illegible]

TABLE XVII.—MALT WORT WITH HOPS.

[illegible]

TABLE XVIII.—BROWN AND PALE MALT WORTS.

[illegible]

TABLE XIX.—VARIOUS WORDS: Mean of Tables XV., XVI., XVII,
and XVIII.

[illegible]

TABLE XX.—MEAN OF TABLES XV., XVI., XVII., and XVIII.

	1	2	3	4	5	6	7	8	9	10
No. xv.	3·2	7·1	11·3	15·6	20·0	24·7	29·6	34·4	39·6	44·8
xvi.	3·9	8·0	12·0	16·3	20·5	25·0	29·8	34·8	40·8	
xvii.	3·0	6·7	10·8	15·0	19·4	23·8	28·3	33·2		
xviii.	3·8	7·9	12·0	16·2	20·5	25·0	29·6	34·4		
Mean	3·5	7·4	11·5	15·8	20·1	24·6	29·3	34·2	40·2	

TABLE XXI.—MALT WORT OF HIGH ORIGINAL GRAVITY WITH HOPS.

Degrees of Spirit-Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0										
1										
2										
3										
4										
5	21·0	21·4	21·9	22·3	22·8	23·2	23·7	24·1	24·6	25·0
6	25·4	25·9	26·3	26·8	27·3	27·8	28·2	28·7	29·1	29·6
7	30·0	30·5	30·9	31·4	31·9	32·3	32·8	33·3	33·8	34·3
8	34·8	35·3	35·8	36·3	36·8	37·3	37·8	38·3	38·8	39·3
9	39·8	40·3	40·8	41·4	41·9	42·4	43·0	43·5	44·0	44·5
10	45·0	45·5	46·1	46·6	47·2	47·7	48·2	48·7	49·3	49·8
11	50·3	50·9	51·4	51·9	52·5	53·0	53·5	54·0	54·5	55·0
12	55·6	56·2	56·7	57·3	57·8	58·3	58·9	59·4	59·9	60·5
13	61·0	61·6	62·1	62·7	63·2	63·8	64·3	64·9	65·4	66·0
14	66·5	67·0	67·6	68·1	68·7	69·2	69·8	70·4	70·9	71·4
15	72·0									

In the examination of fermented liquids, the acetic acid present should not be overlooked, as the influence of this constituent upon the original gravity of some kinds of beer, particularly old and hard beer, is often considerable. There is, however, a certain amount of acid present in all healthy fermentations, and this, in the experiments on which our tables have been founded, was estimated at one part of absolute acetic acid ($C_4 H_4 O_4$) in one thousand parts of wort. Any excess of acid beyond this should be ascertained by neutralizing the beer by an alkaline test-solution. Sixty parts (one equivalent) of acetic acid, represent forty-six parts of absolute alcohol; a proportion by which the weight of alcohol, which has disappeared in the formation of acetic acid, is calculated. This corresponding weight of alcohol has a certain spirit-indication, which is to be added to the spirit-indication of the beer itself before the degrees of gravity lost are taken from the table. The calculated original gravity of old beers is often thus very sensibly increased.

The Tables for calculating original gravities, constructed by Messrs. Dobson and Phillips, were deduced by these gentlemen from observations made upon several different saccharine solutions of known original gravity submitted to fermentation, and are the same in principle as the Tables given in this Report. The old observations appear to have been made with the greatest care and accuracy, and the Table founded upon them, which has been used by the Excise for some time,

is almost identical with Table A, in the Appendix, which we now give as the result of the more numerous and varied experiments subsequently instituted during the present inquiry.

The process of Professor Balling, of Prague, for ascertaining original gravities, forms a part of a general method of analyzing beer which the author has developed in his great work upon Brewing.* The method is remarkable for the number of valuable results which are deduced by calculation from simple observations of the physical properties of the beer, chiefly made by means of the saccharometer. The chemical properties of the extractive matter are not investigated, and the source of the anomalies in the densities of fermented liquids are, therefore, left in the dark. But a certain number of observations have been made on the relation and dependence of the densities of the worts, alcohol, and extractive matter, of particular fermented liquids. These observations afford empirical data for reaching the original gravity, by means of a process of calculation, which is highly remarkable for its ingenuity and success, considering the limited knowledge of the actual chemical changes involved in fermentation. In several samples of beer, to which the formula of Balling was applied by us, it was found to give an original gravity within a single degree of the truth.

Every facility and assistance in pursuing the necessary inquiries respecting fermentation on a large scale were afforded to us by the trade, and we have much pleasure in acknowledging our obligations both to the partners and principal officers of the houses of Messrs. Abbott and Son; Combe, Delafield, and Co.; Furze and Son; Reid and Co.; Thorne and Co.; Truman, Hanbury and Buxton, and Whitbread and Co., of London; and to Messrs. Allsopp and Sons, and Bass and Co., of Burton. We thus obtained the means of verifying the correctness of the original gravities calculated from our tables by means of specimens of beer, of which the original gravity of the worts had been noted with sufficient accuracy, and which had been preserved for a considerable length of time. A series of experiments which had been made by Mr. Croekford, of the Long Acre Brewery, expressly with a view of illustrating the subject of original gravities, and which he placed without reserve at our disposal, and also a long series of most careful observations made by Mr. Bottinger in Messrs. Allsopp's brewery, were particularly pertinent to the inquiry, and afforded a satisfactory confirmation of the sufficiency of the methods.

The methods of determining original gravities already described are essentially empirical. But the investigations respecting the nature of the process of fermentation, into which they have led,

* *Die Gährungschemie wissenschaftlich begründet und in ihrer Anwendung auf die Weinbereitung, Bierbrauerei, Branntweinbrennerei und Hefenferzeugung praktisch dargestellt*, von Carl J. N. Balling. Prague, 1845. Or a shorter treatise by the same author—*Die Saccharometrische Bier- und Branntweinprobe*. Prague, 1846.

suggested the principle upon which the rational process should be founded, and which deserves to be explained for the better illustration of the subject. This process is chiefly interesting in a scientific point of view, as it is too operose and delicate in the form in which it can be at present offered, to supersede the preceding methods which are recommended for practice.

The fact has already been insisted upon, that the alcohol obtained from beer represents a perfectly definite quantity of starch-sugar and nothing else; and so furnishes a portion of the original gravity which is clear and indisputable. The difficulty is with that portion of the original gravity which is represented by the solid matter remaining in the beer. Here also the difficulty would vanish, if that solid matter were either all starch-sugar (which it never is), or entirely composed of the extractive matter already described, as frequently occurs in old hard beer. The gravities of solutions of starch-sugar, and of the extractive matter are different, but are now both fully known. If the solid matter of the beer consisted entirely of the former substance, then the original gravity of the beer would be that of the joint amount of the starch-sugar actually found in the beer, and of that represented by the alcohol of the beer, the whole quantity of sugar being dissolved in water, and having the original volume of the beer. The only further information required might be obtained from a Table of the gravities of solutions of starch-sugar. The specific gravity thus found of the solution of starch-sugar in question, represents the original gravity of the beer.

On the second supposition, that the solid matter of the beer was all extractive matter (without sugar), then the reference should be made to a table of the specific gravities of solutions of different proportions of that substance, such as Table V., page 236, but more extended. In a parallel column the gravities of solutions of starch-sugar possessing the same quantity of carbon as the extractive and corresponding to it, would be placed, and in another column the quantities of starch-sugar in the former solutions of that substance. Such a Table would give at once, therefore, the quantity of starch-sugar corresponding to the extractive, and adding the quantity of starch-sugar represented by the alcohol of the beer, the entire quantity of starch-sugar becomes known, and the original gravity is found from it as in the preceding case.

The problem, therefore, may be solved in the two extreme conditions of the beer which have been supposed. The real difficulty is with the intermediate condition, which is also the most frequent one, where the solid matter of the beer is partly starch-sugar and partly extractive; for no accurate chemical means are known of separating these substances, and so determining the quantity of each in the mixture.

But a remedy presented itself. The fermentation of the beer was completed by the addition of yeast, and the constituents of the beer were thus reduced to alcohol and extractive only, from which the original gravity, as is seen, can be calculated.

For this purpose a small but known measure of the beer, such as four fluid ounces, was carefully deprived of spirits by distillation, in a glass retort. To the fluid, when cooled, a charge of fresh yeast, amounting to 150 grains, was added, and the mixture kept at 80° for a period of sixteen hours. Care was taken to connect the retort, from the commencement, with a tube condenser, so that the alcoholic vapour which exhaled from the wash during fermentation should not be lost. When the fermentation had entirely ceased, heat was applied to the retort to distil off the alcohol; which was collected in a cooled receiver. About three-fifths of the liquid were distilled over for this purpose; and the volume of the distillate was then made up with water to the original volume of the beer. The specific gravity of the last spirituous liquid was now taken, by the weighing bottle. To obtain a correction for the small quantity of alcohol unavoidably introduced by the yeast, a parallel experiment was made with that substance. The same weight of yeast was mixed with water, and distilled in another similar retort. The volume of this second distillate was also made up by water to the beer volume; its specific gravity observed, and deducted from that of the preceding spirituous liquid. This alcohol was added to that obtained in the first distillation of the beer, and the weight of starch-sugar corresponding to the whole amount of alcohol was calculated. This was the first result.

For the solid matter of the beer: the spiritless liquid remaining in the retort was made up with water to the beer volume, and the specific gravity observed. A correction was also required here for the yeast, which is obtained, by making up the water and yeast, distilled in the second retort, to the original volume of the beer, and deducting the gravity of this fluid from the other. The quantity of starch-sugar corresponding to this corrected gravity of the extractive matter was now furnished by the Table, this was the second result.

The two quantities of starch-sugar thus obtained were added together. The specific gravity of the solution of the whole amount of starch-sugar, as found in the Table, represented the original gravity of the beer.

This method must give an original gravity slightly higher than the truth, owing to the circumstance that the dextrin, albumen, and salts, which are found among the solid matters dissolved in beer, are treated as having the low gravity of extractive matter, and accordingly amplified by about one-sixth, like that substance, in allowing for them ultimately as starch-sugar. The error from this source, however, is inconsiderable. It is to be further observed, that the error from imperfect manipulation, of which there is most risk in the process, is leaving a little sugar in the extractive matter from incomplete fermentation. This accident also increases the original gravity deduced. The process has given results which are remarkably uniform, and is valuable in the scientific investigation of the subject, although not of that ready and easy execution which is necessary for ordinary practice, and which recommends the former method. That

method, in its two modifications, has been sufficiently described in the preceding pages, and it now only remains to append the Tables required for its application, which embody the general result of the inquiry.

TABLE A.—To be used in ascertaining Original Gravities by the
DISTILLATION PROCESS.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST
IN MALT WORTS.

Degrees of Spirit- Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·2	·6	·9	1·2	1·5	1·8	2·1	2·4	2·7
1	3·0	3·3	3·7	4·1	4·4	4·8	5·1	5·5	5·9	6·2
2	6·6	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
3	10·7	11·1	11·5	12·0	12·4	12·9	13·3	13·8	14·2	14·7
4	15·1	15·5	16·0	16·4	16·8	17·3	17·7	18·2	18·6	19·1
5	19·5	19·9	20·4	20·9	21·3	21·8	22·2	22·7	23·1	23·6
6	24·1	24·6	25·0	25·5	26·0	26·4	26·9	27·4	27·8	28·3
7	28·8	29·2	29·7	30·2	30·7	31·2	31·7	32·2	32·7	33·2
8	33·7	34·3	34·8	35·4	35·9	36·5	37·0	37·5	38·0	38·6
9	39·1	39·7	40·2	40·7	41·2	41·7	42·2	42·7	43·2	43·7
10	44·2	44·7	45·1	45·6	46·0	46·5	47·0	47·5	48·0	48·5
11	49·0	49·6	50·1	50·6	51·2	51·7	52·2	52·7	53·3	53·8
12	54·3	54·9	55·4	55·9	56·4	56·9	57·4	57·9	58·4	58·9
13	59·4	60·0	60·5	61·1	61·6	62·2	62·7	63·3	63·8	64·3
14	64·8	65·4	65·9	66·5	67·1	67·6	68·2	68·7	69·3	69·9
15	70·5									

TABLE B.—To be used in ascertaining Original Gravities by the
EVAPORATION PROCESS.

DEGREES OF SPIRIT-INDICATION WITH CORRESPONDING DEGREES OF GRAVITY LOST
IN MALT WORTS.

Degrees of Spirit- Indication.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9
0	—	·3	·7	1·0	1·4	1·7	2·1	2·4	2·8	3·1
1	3·5	3·8	4·2	4·6	5·0	5·4	5·8	6·2	6·6	7·0
2	7·4	7·8	8·2	8·7	9·1	9·5	9·9	10·3	10·7	11·1
3	11·5	11·9	12·4	12·8	13·2	13·6	14·0	14·4	14·8	15·3
4	15·8	16·2	16·6	17·0	17·4	17·9	18·4	18·8	19·3	19·8
5	20·3	20·7	21·2	21·6	22·1	22·5	23·0	23·4	23·9	24·3
6	24·8	25·2	25·6	26·1	26·6	27·0	27·5	28·0	28·5	29·0
7	29·5	30·0	30·4	30·9	31·3	31·8	32·3	32·8	33·3	33·8
8	34·3	34·9	35·5	36·0	36·6	37·1	37·7	38·3	38·8	39·4
9	40·0	40·5	41·0	41·5	42·0	42·5	43·0	43·5	44·0	44·4
10	44·9	45·4	46·0	46·5	47·1	47·6	48·2	48·7	49·3	49·8
11	50·3	50·9	51·4	51·9	52·5	53·0	53·5	54·0	54·5	55·0
12	55·6	56·2	56·7	57·3	57·8	58·3	58·9	59·4	59·9	60·5
13	61·0	61·6	62·1	62·7	63·2	63·8	64·3	64·9	65·4	66·0
14	66·5	67·0	67·6	68·1	68·7	69·2	69·8	70·4	70·9	71·4
15	72·0									

The Tables to be used for liquids fermented from cane-sugar and for liquids fermented from starch-sugar, are given at pages 242—3 of the Report for the distillation process, and at page 250 for the evaporation process.

Researches on some of the Crystalline Constituents of Opium.***By Thomas Anderson, M.D., F.R.S.E.**

(Abstracted by the Author.)

Opium has been already submitted to investigation by so many chemists, that it may at first sight appear to be an almost exhausted subject; but when we inquire more minutely into its history, the meagre and often conflicting statements of different observers sufficiently indicate the necessity of more extended and minute inquiries, before our knowledge of it can be considered as either definite or satisfactory. No less than ten† basic and indifferent substances have been extracted from it; and of these, the constitution of four only, namely, morphine, codeine, papaverine, and narcotine, has been satisfactorily established. Of the remaining six, porphoroxine is still unanalysed; opianine is of recent discovery, and its composition still doubtful; while the formulæ attributed to thebaine, pseudomorphine, narceine, and meconine, are founded on old analyses, made soon after their discovery, at a time when the methods of organic analysis were comparatively imperfect, and certainly cannot be looked upon as very satisfactory.

For the preparation of the bases which form the subject of the following paper, I have made use of the black mother-liquor of the preparation of muriate of morphine, by the process of Robertson and Gregory. This fluid, which is perfectly black, and of the consistence of tar, is diluted with water, and filtered for the separation of a small quantity of flocky substance which deposits. Ammonia is then added as long as a precipitate is obtained, which is separated by filtration through cloth, and subjected to strong pressure. The precipitate thus obtained is dark-coloured and granular, but if left in the press for any length of time, is apt to run into a resinous mass. It must therefore be rapidly removed, broken up with a small quantity of water, and again expressed; and this is repeated several times. The precipitate contains narcotine, along with a considerable quantity of resin, and a small quantity of thebaine. The fluid contains narceine, and must be preserved for its preparation.

A portion of the precipitate is boiled with rectified spirit, and filtered hot; on cooling, impure and highly-coloured crystals of narcotine are deposited, which are collected on a cloth, washed with a small quantity of alcohol, and expressed; the mother-liquor of these crystals is employed for the solution of another quantity of the precipitate, and so on until the whole has been dissolved. The impure crystals of narcotine are then rubbed up with a small quantity of a strong solution of potash, and after standing for some time, washed

* Trans. Royal Society, Edinburgh, XX, [3], 347.

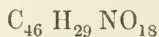
† Since this paper was written, two new substances have been added to the constituents of opium; these are, the methylonarcotine and propylonarcotine of Wertheim.

with water, and finally crystallised several times from boiling spirit. The alcoholic solution from which the first dark-coloured crystals of narcotine are deposited, on being distilled in the water-bath, leaves behind a dark amorphous mass, containing much resin, mixed with a little narcotine, and the whole of the thebaine contained in the original precipitate. It is treated with hot dilute acetic acid, which dissolves the bases and a small quantity of resin. To this solution subacetate of lead is added until it acquires a distinctly basic reaction, when the whole of the narcotine and resin are deposited, and the thebaine remains in solution. The fluid is filtered from the precipitate, the excess of lead thrown down by sulphuric acid, the sulphate of lead separated by filtration, and the thebaine precipitated by ammonia. The washed precipitate is then dissolved in boiling alcohol, and treated with animal charcoal, and on cooling, the fluid becomes filled with shining plates, which are purified by several crystallisations.

The mother-liquor of the original ammonia-precipitate contains narceine, which is obtained in the following manner. A solution of acetate of lead is added to the fluid, and the dirty brownish precipitate formed, separated by filtration. The excess of lead is separated by sulphuric acid, and the fluid, saturated with ammonia, is set to evaporate at a moderate temperature. When it has reached a certain degree of concentration, a film appears on the surface, and on cooling a quantity of crystalline matter is deposited, which becomes more abundant on being allowed to stand for some days. This substance is collected on a cloth and washed with water, and is then sometimes quite colourless, but has more frequently a somewhat brown colour. It is then boiled with a large quantity of water, and filtered hot; and on cooling, the fluid becomes filled with fine silky crystals of narceine, which are separated from traces of sulphate of lime by solution in alcohol, and after boiling with animal charcoal and resolution in water are pure.

NARCEINE.

Narceine has been already analysed, both by Pelletier and Couerbe; and from their results the former has deduced the formula $C_{32} H_{24} NO_{16}$, the latter $C_{28} H_{20} NO_{12}$, which, though agreeing tolerably well with their analytical results, are unsupported by determination of the atomic weight, which neither of them appear to have attempted, owing to the impression they derived from their experiments, that narceine is incapable of entering into combination with acids. My own experiments give for it the formula:



which was substantiated by the analysis of its platinum compound,

which was found to contain 14.56 per cent of platinum, and gave for the atomic weight of the base 464.8, while the theoretical number is 463.

Narceine crystallises in delicate silky needles, which mat together into a bulky mass. These crystals are always extremely white; and narceine is remarkable for the facility with which it is obtained colourless. In cold water it is sparingly, and in hot water readily soluble, and the solution on cooling becomes filled with a network of bulky crystals. It is more soluble in alcohol, and insoluble in ether. Ammonia and dilute solutions of potash and soda dissolve it in larger proportion than water; but the addition of a large quantity of concentrated potash precipitates it, even from a hot solution, in the form of an oily mass, which remains fluid for some time under the solution. When boiled with dilute nitric acid, the fluid acquires a yellow colour, and on saturation with potash, the odour of a volatile base is evolved. Concentrated nitric acid acts violently in the cold, and oxalic acid is found in the solution. Strong sulphuric acid dissolves it in the cold with an intense red colour, which passes into green on the application of heat. Strong hydrochloric acid dissolves it entirely, without producing the blue colour described by Pelletier as characteristic of narceine. I did obtain a blue colour on one occasion, but it was when operating on an impure specimen, and I have never succeeded in obtaining it again; I have been equally unsuccessful with a specimen obtained directly from the establishment of Robiquet, Pelletier and Caventou. This specimen differed in some respects from that which I had myself prepared, and a single analysis gave results corresponding with the formula $C_{32} H_{19} NO_{10}$; but I have no means of confirming its correctness, as the high price of the material deterred me from further experiments.

Hydrochlorate of Narceine is obtained sometimes in large groups of radiated needles, and sometimes in the form of short thick irregular prisms. They are soluble in both water and alcohol, and possess a distinctly acid reaction. Dried at $212^{\circ} F.$, they have the formula $C_{16} H_{29} NO_{18} \cdot H Cl$.

Sulphate of Narceine is deposited in tufts of silky needles, not differing much in appearance from the base itself. It is rather sparingly soluble in cold water, readily in hot.

Nitrate of Narceine is deposited in radiated groups from its hot solution. It is rather sparingly soluble in the cold.

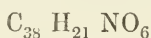
Chloride of Platinum and Narceine.—When a solution of chloride of platinum is added to hydrochlorate of narceine, the double compound makes its appearance, sometimes as a crystalline powder, sometimes in small prismatic crystals. Their formula is $C_{46} H_{29} NO_{18} \cdot HCl \cdot Pt Cl_2$.

THEBAINE.

Three different formulæ have been given for thebaine by Pelletier, Couerbe and Kane. They are :

Pelletier	.	.	$C_{34} H_{18} NO_6$
Couerbe	.	.	$C_{25} H_{13.5} NO_4$
Kane	.	.	$C_{25} H_{14} NO_3$

The atomic weight has been determined by the two latter chemists by ascertaining the quantity of hydrochloric acid gas absorbed by the base ; Couerbe found 100 parts to absorb 8.35 of acid, while Kane found it to absorb at $212^{\circ} F.$, 16.96 per cent, and at ordinary temperatures, 33.28. These results are very nearly in the proportion of 1, 2 and 4 ; but no reliance can be placed upon them, as I have found that thebaine is very readily decomposed by hydrochloric acid, and none of them agree with the atomic weight deduced from my own experiments. My analysis gives for it the formula :



differing from that of codeine by two equivalents of carbon.

Thebaine crystallises from its alcoholic or ethereal solution in brilliant square plates having a silvery lustre. It is insoluble in water, but very soluble in alcohol or ether, especially on boiling. It dissolves readily in acids, and forms salts which are not obtained in crystals from aqueous solutions. It is insoluble in potash and ammonia. Strong sulphuric acid reacts upon it, and produces a deep-red colour, even when it is free from nitric acid. Concentrated nitric acid acts violently in the cold, with copious evolutions of red fumes, and formation of a yellow solution, which becomes dark-coloured on the addition of potash, and evolves a volatile base. In hydrochloric acid it dissolves readily, and the solution on evaporation becomes dark-coloured, and leaves behind a resinous matter, which does not dissolve completely in water. Sulphuric acid, of specific gravity 1.300, dissolves it in the cold ; and on gently heating, a resinous or semi-solid matter is thrown down, which, on boiling with water, slowly dissolves, and deposits, on cooling, a rather sparingly soluble salt, in microscopic crystals, which appears to be a product of decomposition, but of which I must defer the examination, until I have obtained an additional quantity of thebaine. Chlorine and bromine rapidly decompose thebaine with the formation of resinous compounds.

Hydrochlorate of Thebaine.—In order to prepare this salt, thebaine is mixed with a small quantity of strong spirit and an alcoholic solution of hydrochloric acid added, until the thebaine is dissolved, an excess being avoided, and on standing, the salt is deposited in fine rhomboidal crystals. They are very soluble in water, and the solu-

tion, on evaporation, yields only a resinous mass. In alcohol, especially if absolute, they are rather sparingly soluble, and in ether they are insoluble. Dried at 212° F., their formula is $C_{38} H_{21} NO_6 \cdot HCl + 2HO$.

Platinochloride of Thebaine is thrown down as a yellow crystalline powder on the addition of chloride of platinum to the preceding compound. It is sparingly soluble in hot water, and the solution on cooling, deposits a salt which appears to be a product of decomposition. The formula of the salt dried at 212° is $C_{38} H_{21} NO_6 \cdot HCl \cdot Pt Cl_2 + 2HO$.

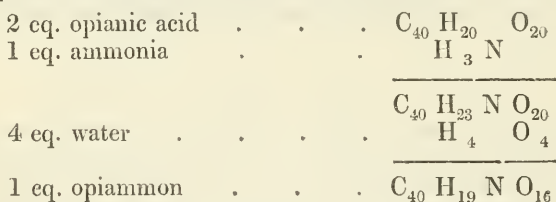
Sulphate of Thebaine is obtained by adding sulphuric acid to an ethereal solution of thebaine, partly in crystals, partly as a resinous mass, becoming crystalline on standing. The hydrochlorate gives with corrosive sublimate, a fine, white, crystalline precipitate of a double salt, and the base itself gives a bulky precipitate; but neither of these substances could be obtained of constant composition. Terechloride of gold gives an orange-yellow precipitate, which fuses at 212° into a resinous mass.

ACTION OF NITRIC ACID ON NARCOTINE.

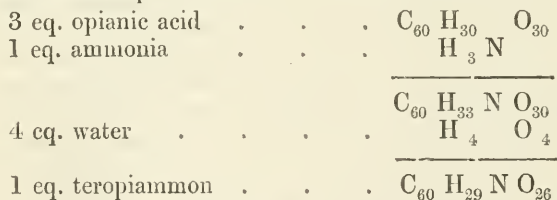
When concentrated nitric acid is added to narcotine, a very violent action ensues; even in the cold, red fumes are copiously evolved, and a thick, resinous-looking red matter is left behind. With somewhat weaker acid and a gentle heat, a similar action takes place, and a red fluid is obtained, which, by evaporation, yields an amorphous orange residue. In both cases, the action was much too violent, and the product obtained obviously the result of several complex actions. The action of nitric acid in a more dilute state was therefore tried, and after several experiments, the following was found to be the most advantageous method of treatment. Six hundred grains of narcotine are mixed with $2\frac{1}{2}$ ounces, by measure, of nitric acid, of specific gravity 1.400, diluted with ten ounces of water, and exposed in the water-bath to an uniform temperature of 120° Fahr. The narcotine fuses into a yellowish mass, which, by continuous agitation, slowly dissolves without the evolution of red fumes. When the solution is nearly complete, a small quantity of a white deposit begins to make its appearance in the solution, and gradually increases in quantity until the fluid becomes filled with bulky crystalline flocks. The quantity of this substance produced appears to depend, to a great extent, upon the rapidity of the oxidation, being sometimes extremely minute, and always bearing a very small proportion to the quantity of narcotine employed. When these flocks have ceased to increase in quantity, they are separated from the fluid by filtration through asbestos, washed with water, in which they are insoluble, and purified by solution in a considerable quantity of boiling alcohol.

To this substance I give the name of *Teropiammon*. As thus

obtained, it is in the form of very small colourless needles, insoluble in water; sparingly soluble in cold, and more soluble in boiling alcohol. It is little soluble in ether. Concentrated sulphuric acid dissolves it in the cold, and the solution, which is yellow, gives a fine crimson on being heated. Nitric acid decomposes it. Hydrochloric acid and ammonia have no action on it. Boiled with potash, ammonia is evolved, and opianic acid is found in the solution. I at first considered it identical with Wöhler's opiammon, but the absence of xanthopenic acid in this reaction, and various other differences, convinced me that it was not the same, and this was confirmed by analysis, which gave for it the formula $C_{60} H_{29} NO_{26}$. That it is actually different from Wöhler's opiammon, of which the formula is $C_{40} H_{19} NO_{16}$, is very obvious, but it bears an interesting relation to it. The latter substance is derived from two equivalents of opianic acid and one equivalent of ammonia, by the removal of the elements of four equivalents of water as thus represented:



and the new compound is derived in a precisely similar manner from three equivalents of opianic acid:



Both these substances, therefore, are produced in a similar manner from different opianates of ammonia; and it is in consideration of this constitution that I give to my compound the name of *teropiammon*, while I should propose that of *binopiammon* for Wöhler's substance, and leave the name of *opiammon* for the compound similarly obtained from a single equivalent of opianic acid, should it ever be discovered. The production of teropiammon in a highly acid fluid is a very remarkable phenomenon, and one, so far as I know, of which we have no other example. It is obviously the result of a secondary action, but it has appeared to me that it was most abundantly produced when the action of the nitric acid was most moderate, and I have never succeeded in obtaining it in larger quantity by continuing the action further.

The fluid from which teropiammon has been separated is yellow, and on supersaturation with potash, deposits a crystalline powder. This was found to be cotarnine, which can be obtained in this way much more readily than by Wöhler's process.

In the alkaline fluid from which the cotarnine had been separated, it was natural to look for opianic acid, and its presence was soon established, as well as that of hemipinic acid, and another substance, which I call *Opianyl*. These substances were not, however, invariably all present, opianic acid and opianyl being sometimes entirely absent, and the latter being only found when the conditions of the oxidation were very successfully fulfilled. To obtain these substances, the alkaline fluid is evaporated to a small bulk and the crystals of nitre which form are separated. The syrupy mother-liquor is treated with alcohol, to separate carbonate of potash, the alcohol distilled off, and hydrochloric acid added to the cold residue, when there is obtained a precipitate containing opianic and hemipinic acids and opianyl.

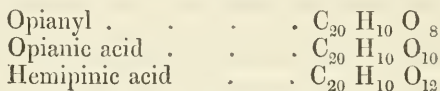
OPIANYL.

This substance is only formed when the oxidation has been extremely gentle, and, though repeated trials have been made, it has been found impossible to moderate the action in such a way as to produce it at will. In order to obtain it in a pure state, the precipitate by hydrochloric acid, which has just been referred to, is dissolved in a large quantity of boiling water, and the solution allowed to cool. A crop of crystals is deposited which consists of opianyl along with some opianic acid, if the quantity of water employed has not been sufficiently large. These crystals are purified by solution in boiling water and in alcohol. In one instance, opianyl was obtained along with hemipinic acid, and with only traces of opianic acid; and in that case, its purification was conveniently effected by dissolving in boiling water, precipitating hemipinate of lead with a solution of neutral acetate of lead, washing the precipitate in boiling water, and evaporating to a small bulk, when opianyl deposited in colourless crystals, which were purified by solution in boiling water.

Opianyl is thus obtained in long, colourless needles, which are sparingly soluble in cold, more so in hot water. When boiled with a quantity of water insufficient to dissolve it, it melts under the fluid, but when dry it requires a temperature of 230° Fahr. to produce its fusion, and resolidifies at 220° . It dissolves both in alcohol and ether. Sulphuric acid dissolves it in the cold, and the colourless solution acquires a fine and characteristic purple colour on heating. Boiling nitric acid decomposes it. It is not more soluble in potash, soda, and ammonia than in water, and forms no compounds with the metallic oxides. Its analysis gave results corresponding to the formula

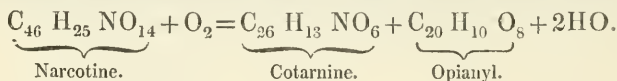


Opianyl thus bears an interesting relation to opianic and hemipinic acids, provided we assume for the former the formula as corrected by Berzelius, and, for the latter, an atomic weight twice as high as that assigned to it by Wöhler, both of which are consistent with my analyses. The three substances then stand as follows :



and appear as three successive degrees of oxidation of the same radical.

The derivation of opianyl from narcotine is abundantly simple. Two equivalents of hydrogen are oxidised by the nitric acid, and the narcotine splits up into opianyl and cotarnine, as thus expressed :



The same scheme, with the addition of two or four equivalents of oxygen, represents also the mode in which opianic and hemipinic acids respectively are derived from narcotine much more simply than it has been by Blyth, in his paper on the action of bichloride of platinum on narcotine, who gives a scheme involving the evolution of carbonic acid. The appearance of this gas, which was actually observed by Blyth during the action, has, however, always appeared to me to be the result of a secondary decomposition ; and this view, I think, receives confirmation from the production of teropiammon, where nitric acid acts even in the most feeble manner on narcotine, and the formation of which must, of necessity, be attended by the evolution of carbonic acid.

If we pursue the relations of opianyl to narcotine, we shall find that these also are of a very interesting nature. By subtracting an equivalent of cotarnine from one of narcotine,



we find that the substance coupled with cotarnine to form narcotine may be considered as a *hydruret* of opianyl, or a substance bearing to opianyl a relation similar to that which alloxantin bears to alloxan, and the preparation of which, in a separate form, would be most interesting. The attempts which I have made to obtain it have, however, as yet proved abortive. I have tried the action of sulphuretted hydrogen upon opianyl, but no change took place, and also the fer-

mentation of narcotine, but with equally little success. It is possible that Wöhler's sulphopianic acid $C_{20}H_{10}O_8 + S_2$, may have some relations with this substance, and in this point of view deserves a more extended examination.

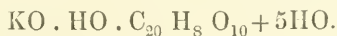
Hydrate of Opianyl.—On one occasion I obtained by acting on narcotine, a substance similar in most of its properties to opianyl, but which fused at $205^\circ F$. Its analysis corresponded to a hydrate of that substance $C_{20}H_{10}O_8 + HO$, but I did not again obtain it, and I had not enough for a detailed examination.

Opianic Acid is obtained by evaporating the fluid which has deposited opianyl. I have repeated its analysis for the purpose of fixing its formula, and the results agree with $C_{20}H_{10}O_{10}$, the quantity of hydrogen being much too high for Wöhler's formula, $C_{20}H_9O_{10}$, although every care was taken in drying the material employed.

Opianic Ether.—According to Wöhler, opianic ether cannot be obtained by the action of sulphuric or hydrochloric acid upon a mixture of opianic acid and alcohol; but I obtained it by chance, with the latter acid, and have confirmed its composition and found it to possess the properties attributed to it by the discoverer.

Hemipinic Acid.—The analytical results obtained by Wöhler for this acid I have fully confirmed, but I have found it to be a bibasic acid, and its rational formula to be $C_{20}H_{10}O_{12}$, or double of that given by him. This result is deduced from the analysis of an acid hemipinate of potash, and from the formation of a hemipinovinic acid.

Acid Hemipinate of Potash is obtained in the form of thick, six-sided tables, sometimes of considerable size, which are readily soluble in water and alcohol, but not in ether. It is highly acid to test-paper. The crystallised salt is represented by the formula:



Neutral Hemipinate of Potash is highly soluble and crystallises with difficulty.

Hemipinovinic Acid is prepared by passing a current of hydrochloric acid through a solution of hemipinic acid in absolute alcohol. It is obtained in the form of tufts of bulky needles, sparingly soluble in cold, more so in hot water. It fuses at 270° Fahr., but melts under water into a transparent fluid. It is strongly acid to test-paper. Its aqueous solution does not precipitate the salts of lead and silver, but gives, with perchloride of iron, a bulky, pale, brownish-yellow precipitate. It dissolves readily in potash, and the solution, on boiling, evolves alcohol. The crystallised acid has the formula, $C_4H_5O \cdot HO \cdot C_{20}H_8O_{10} + HO$. Although it possesses distinctly acid properties, and is capable of uniting with bases, I have failed in obtaining its compounds in a state of purity. Its baryta-salt was obtained in tufts

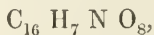
of minute needles by digesting a solution of the acid with carbonate of baryta. But the compound was not obtained in a state fitted for analysis, and appears to be very liable to undergo decomposition.

ACTION OF NITRIC ACID ON COTARNINE.

The products of the action of nitric acid on cotarnine are extremely complex, and several different actions appear to occur simultaneously, in each of which a different decomposition is produced. When the concentrated acid is employed, oxalic acid is produced; but when it is more dilute, another acid is obtained, which remains in solution in the nitric acid.

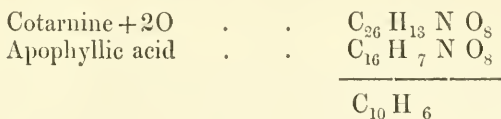
The preparation of this substance is a matter of considerable nicety, and it is particularly important that the nitric acid be not employed in too large an excess, partly on account of the risk of carrying the action too far, and partly on account of the difficulty of separating the product from a very large excess of acid. As the new product is liable to undergo a further oxidation, with production of oxalic acid, it is not safe to attempt its separation by evaporating the nitric acid solution. The best method is to dissolve the cotarnine in nitric acid diluted with about twice its bulk of water, and then adding strong nitric acid, to raise the mixture to the boiling-point. Red fumes are copiously evolved, and after some time, a little of the fluid is taken out and mixed with a considerable quantity of alcohol and ether. If, on standing for a short time, crystals are deposited, the whole fluid is treated in the same manner; but if they do not appear, the digestion is continued somewhat longer, and it is tried again, and so on, until the right point is attained. The fluid, mixed with alcohol and ether, is allowed to stand for twenty-four hours, and the precipitated crystals are separated by filtration. This substance agrees in all respects with the apophyllic acid obtained by Wöhler as a product of the action of bichloride of platinum upon cotarnine, but which he obtained in too small a quantity for examination and analysis.

Apophyllic Acid.—The acid, after being purified by crystallisation, and, if necessary, by animal charcoal, presents all the characters attributed to it by Wöhler, and may be obtained either in hydrated or anhydrous crystals. It is soluble in water, but not in alcohol or ether. It dissolves, also, in concentrated sulphuric acid. It fuses at 401° F., and on cooling solidifies into a crystalline mass. All its salts are extremely soluble. Its analysis gave results corresponding with the formula

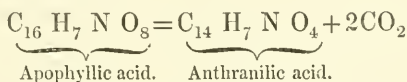


which has been confirmed by the analysis of its silver-salt. Its formation from cotarnine cannot be distinctly traced, as several other substances are formed simultaneously, which I have not examined;

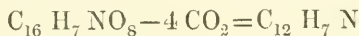
but if we add to cotarnine two equivalents of oxygen and subtract from it the formula of apophyllic acid, the difference is $C_{10} H_6$:



I have been unable to ascertain whether this group of atoms passes into any particular form of combination, or whether it is entirely oxidised, which is possible. In its composition, apophyllic acid is curiously related to anthranilic acid, from which it differs by two equivalents of carbonic acid.



According to Wöhler, apophyllic acid, when distilled, yields a quantity of *Chinoline*; but now that its constitution is known, we should rather expect the production of aniline, which would be formed from it by the removal of four equivalents of carbonic acid, thus :



By distillation I obtained a quantity of a base which had a slightly aromatic odour, but gave no reaction of aniline with chloride of lime. I did not obtain it in sufficient quantity for analysis. It is not the only product of decomposition, a non-basic oil making its appearance at the same time.

Apophyllate of Silver.—This salt can only be obtained by digesting the acid with moist carbonate of silver, and precipitating with a mixture of alcohol and ether. It is thrown down as a crystalline powder, which is very soluble in water, and insoluble in alcohol and ether. It does not explode when heated, but burns slowly and leaves metallic silver. It is represented by the formula $AgO \cdot C_{16} H_6 NO_7$.

Apophyllate and Nitrate of Silver.—When a solution of nitrate of silver is added to an alkaline apophyllate, a sparingly soluble crystalline salt is obtained, which explodes violently when heated, and has been described by Wöhler as apophyllate of silver. It is, however, a compound of that salt with the nitrate of silver, and is represented by the formula $AgO \cdot C_{16} H_6 NO_7 + AgO \cdot NO_5$.

Apophyllate of Ammonia forms very small prismatic needles, highly soluble in water.

Apophyllate of Baryta is obtained by digesting the acid with carbonate of baryta, and adding alcohol to the fluid, when it is precipitated in wart-like crystals.

Associated with apophyllic acid, another substance was once

obtained in yellow needles, the analysis of which gave results corresponding with the formula $C_{36}H_{13}NO_{14}$, but want of material has prevented its further examination, and on another occasion a third substance was detected. Both these substances deserve further examination.

When the solution from which the apophyllic acid has been thrown down is distilled, a syrupy fluid is obtained, which, on the addition of potash, evolves the odour of a volatile base. In order to obtain this base, a considerable excess of potash was added to the syrupy fluid, and the whole distilled. A highly alkaline fluid passed into the receiver, which was saturated with hydrochloric acid, evaporated, and the residue dissolved in absolute alcohol. The alcohol, on distillation, yielded a salt in fine scales, which gave a fine golden-yellow double salt with bichloride of platinum, and proved on analysis to be the platinum compound of methylamine. On another occasion the presence of ethylamine was detected; and indications of another base, with a much higher atomic weight, were also obtained.

The following is a tabular statement of the substances described in the paper.

Narceine	$C_{46}H_{29}NO_{18}$
Hydrochlorate of narceine	$C_{46}H_{29}NO_{18} \cdot HCl$
Platinochloride of narceine	$C_{46}H_{29}NO_{18} \cdot HCl \cdot PtCl_2$
Robiquet's narceine	$C_{32}H_{19}HO_{10} (?)$
Thebaine	$C_{38}H_{21}NO_6$
Hydrochlorate of thebaine	$C_{38}H_{21}NO_6 \cdot HCl + 2HO$
Platinochloride of thebaine	$C_{38}H_{21}NO_6 \cdot HCl \cdot PtCl_2 + 2HO$
Teropiammon	$C_{60}H_{29}NO_{26}$
Opianyl	$C_{20}H_{10}O_8$
Hydrate of opianyl	$C_{20}H_{10}O_8 + HO$
Opianic acid	$C_{20}H_{10}O_{10}$
Opianic ether	$C_4H_5O \cdot C_{20}H_9O_9$
Hemipinic acid	$C_{20}H_{10}O_{12}$
Acid hemipinate of potash	$KO \cdot HO \cdot C_{20}H_8O_{10}$
Hemipinate of silver	$2AgO \cdot C_{20}H_8O_{10}$
Hemipinovinic acid	$HO \cdot C_4H_5O \cdot C_{20}H_8O_{10}$
Apophyllic acid	$C_{16}H_7NO_8$
Apophyllate of silver	$AgO \cdot C_{16}H_6NO_7$
Methylamine	C_2H_5N
Ethylamine	C_4H_7N

On the extraction of Oxygen Gas from Atmospheric Air.***By M. Boussingault.**

It is somewhat remarkable that no attempt has ever been made to obtain oxygen from the atmosphere in quantity sufficient for any useful purpose. In fact, the celebrated experiment of Lavoisier, in which he converted mercury into the red oxide, by boiling it for a long time in the air and afterwards decomposing the resulting oxide at a red heat, appears to be the only instance in which the oxygen of the air has actually been separated from the nitrogen, and exhibited in the free state; and it is scarcely necessary to observe, that the quantity yielded by this process, is insufficient for any purpose beyond the mere demonstration of the fact.

Among the very few substances which might be made available for the actual separation of oxygen from the air, baryta appears to present the greatest advantages, from its well known property of absorbing oxygen readily from the air at a low red heat, and passing to the state of peroxide of barium, which, on subsequent exposure to a full cherry-red heat, gives up its second atom of oxygen, and is reconverted into baryta. The baryta may thus be reoxidised at a low red heat, once more restored to its original state at a higher temperature, and thus the process may be made continuous.

The apparatus used for carrying this process into effect, consists of a tube of porcelain, or glazed earthenware, inserted through a dome-furnace. The baryta is introduced in fragments into this tube, at the entrance to which is placed a stopcock to regulate the access of air. To the other end of the tube are adapted two exit-tubes, also furnished with stopcocks; the one communicating with an aspirator, the other with a gasometer.

The tube is first raised to a dull red heat, and the air made to pass through it, by allowing the water to run from the aspirator; the baryta then becomes oxidised. After a certain time, when the oxidation is thought to be sufficiently advanced (it need not be complete), the stopcock which admits the air, and likewise the stopcock of the aspirator are closed, and communication is established between the tube and the gasometer. The temperature is then raised by opening the ash-door of the furnace, and after a short time, the oxygen which the baryta had absorbed is given off, and passes into the gasometer. When the disengagement of gas is finished (and it is very rapid), the gasometer is closed, the fire lowered by closing the ash-door, and the aspirator again set in action. By this means the baryta is reoxidised, and will then give up a fresh portion of oxygen on being more strongly heated; and these two operations may be continually repeated. The baryta, in fact, at a red heat, acts

* Ann. Ch. Phys. [3], XXX, 5; Compt. rend. XXX, 261 and 821.

as a filter, which retains the oxygen of the air and lets the nitrogen pass.

In the course of the experiments made with this apparatus, it was found that the baryta, after having been used several times, and occasionally even after the second operation, lost, in a great measure, its power of absorbing oxygen. This diminution of absorbing power was equally apparent when the baryta was oxidised in a current of air carefully freed from water and carbonic acid, and even when the oxidation was effected by a stream of pure oxygen; hence it was not due to any change produced in the baryta by carbonic acid, water, or other impurities in the air. It was for some time attributed to a partial fusion or vitrification taking place at the surface of the baryta, in consequence of the presence of silica and alumina derived from the earthen vessels in which the baryta was calcined. More careful experiments, however, showed that, with perfectly pure baryta, calcined in platinum vessels, the same diminution of absorbing power was apparent.

The true cause of the diminution was ultimately found in the gradual, but complete desiccation which the baryta undergoes by the continued passage of dry air over it. In fact, M. Boussingault's experiments show that pure anhydrous baryta has very little tendency to absorb oxygen; but that the hydrate, when heated to dull redness in a current of air, readily gives up its water, and is converted into peroxide of barium.

Now, baryta prepared in the ordinary way is never perfectly dry; for though in calcining the nitrate, any water that may be present is driven off by the heat, the baryta nevertheless absorbs more or less water as it cools—more especially as, in order to remove it from the crucible, it is necessary to break it up. Now, this partially hydrated baryta, when first subjected to the action of the air at a low red heat, absorbs oxygen with facility; but as its water is gradually abstracted, its power of absorption becomes less and less.

The easy conversion of hydrate of baryta into peroxide of barium by a current of dry air, joined with the well-known fact, that the peroxide is readily converted into the hydrate by boiling water or its vapour, suggests the means of separating the oxygen of the air at a much lower temperature than by the process already described, thereby economising fuel, and avoiding the destructive action which the baryta exerts upon the earthenware tubes at high temperatures. In fact, the decomposition of the hydrate, and oxidation of the baryta, take place at a dull red heat; and the decomposition of the peroxide by vapour of water may be effected at a still lower temperature, viz., at 100° C.

In carrying out this process, however, considerable difficulty was experienced from the extreme fusibility of the hydrate. This substance becomes liquid at a red heat; hence it was necessary to place it in a long silver boat, occupying the whole length of the heated portion

of the porcelain tube; but in a short time, the crust of peroxide formed on the surface, opposed so great an obstacle to the action of the air, that the oxidation took place very slowly. This inconvenience was ultimately remedied by mixing the hydrate of baryta with hydrate of lime, or with magnesia.

The mixture is introduced into a porcelain tube, and kept in its place by two plugs of asbestos. It is then oxidised by a rapid current of air, the tube being kept at a dull red heat; and when the oxidation has proceeded far enough, the connexion with the gasometer is established, and a jet of steam introduced into the tube from a small boiler disposed for the purpose. The peroxide of barium is then immediately reconverted into hydrate of baryta, and the excess of oxygen is given off. The baryta is then reoxidised by a fresh current of air, again deoxidised by vapour of water, and thus the process is made continuous.

Baryta thus treated appears to retain its power of absorbing oxygen for any length of time.

In the process just described, we have perhaps an example of the influence of mass in chemical decomposition. In the one case, a large quantity of air expels the water from hydrate of baryta, and puts oxygen in its place; in the other, at the same temperature, a continuous current of vapour of water expels the oxygen from peroxide of barium, and reconverts it into hydrate of baryta.

This mode of extracting oxygen from the air has hitherto been used only in laboratory experiments; but there appears to be no reason against its use on the large scale. In fact, 10 kilogrammes of baryta, if completely oxidised and deoxidised, will yield 730 litres of oxygen gas; and even supposing that, for the sake of quickness of operation, this quantity were reduced to 600, we might, by operating on 100 kilogrammes of substance heated in eight or ten cylinders, obtain at each deoxidation, 6000 litres of oxygen; and supposing four or five such operations to be gone through in four-and-twenty hours, the product would be from 24,000 to 30,000 litres of gas (or, in English measures, from 5000 to 6000 gallons of gas from 8 or 9 cwt. of baryta).

As baryta is now prepared in large quantities, its use would not present any difficulty; but in order that the process may be advantageously conducted on the manufacturing scale, there are still many points to be determined. Thus it would be necessary to determine the manner in which the oxidation is affected by the velocity of the current of air, and whether it would not be advisable to use hot air in order to accelerate the operation, and avoid loss of heat. The necessity for the presence of water in the oxidising process may be considered as established; but it still remains to determine the quantity of vapour which the air should contain, in order to act to the greatest advantage.

Electro-Chemical Researches on the Properties of Electrified Bodies.***By E. Fremy and E. Becquerel.**

For some years, the attention of chemists has been directed to the singular modifications which certain bodies present when submitted to the action of a moderately elevated temperature. It is known, for example, that sulphur and phosphorus, when thus treated, acquire new properties. The authors propose to examine, in a series of memoirs, whether electricity is capable of altering the physical and chemical characters of bodies in a similar manner to heat; and have, in the first place, directed their attention to the remarkable effects presented by oxygen under certain circumstances, and commonly attributed to the formation of a peculiar principle, called *Ozone*. This body appears, in fact, to be produced whenever oxygen is subjected to electrical influence; but its production, or the effects attributed to it, take place in different degrees according to the kind of electricity employed.

1. The voltaic battery cannot be used for determining the nature of ozone, because the amount of the active principle existing in the oxygen thereby obtained is very small.

2. The arc formed on breaking the voltaic current, does not appear to modify oxygen in the same manner as the ordinary spark, probably because the rise of temperature which accompanies it, destroys what the electricity might produce. It appears, however, that the voltaic arc is capable of inducing the combination of gases, acting, in fact, like spongy platinum, or the common electric spark. The authors have, by means of the voltaic arc, induced the direct combination of nitrogen with oxygen, to form nitric acid; of hydrogen with nitrogen, to form ammonia; and of sulphurous acid with oxygen, to form anhydrous sulphuric acid.

3. The spark proceeding from induced currents, and produced by means of the apparatus lately constructed by M. Ruhmkorf, acts like the spark of the ordinary electrical machine, and enables the operator to repeat, without fatigue, all the experiments which can be made with the machine.

4. Pure oxygen enclosed in glass tubes, together with a strip of paper saturated with starch and iodide of potassium, may be electrified by induction, by means of a succession of sparks passing along the external surface of the tube; the paper begins to turn blue after the passage of a few sparks. This colouring is due to the electrization of the oxygen, and not to any electrolytic decomposition of the iodide; for when the experiment is made in an atmosphere of hydrogen, no bluing is produced. This fact is the more remarkable, inasmuch as

* Ann. Ch. Phys. [3], XXXV, 62; *abstr.* Compt. Rend. XXXIV, 399; J. Pharm. [3], XXXI, 321.

the oxygen is electrified without the intervention of metallic wires, and consequently when there can be no transference of particles by the spark.

5. Oxygen prepared by the most various methods, *e. g.*, by calcining the oxides of manganese, mercury, and silver, by the decomposition of chlorate of potash, and by the electrolysis of water, acquires a peculiar odour and very decided oxidating powers when subjected to the influence of electricity; these properties are exhibited by oxygen in the greatest state of purity obtainable. Oxygen thus electrified, loses its oxidating properties when placed in contact with iodide of potassium; but its odour and oxidizing powers may be restored by fresh electrization; this experiment may be repeated any number of times with the same gas.

These facts show that the oxidating power of electrified oxygen is not due to the presence of any foreign substance in the gas. The following experiments were made for the purpose of rendering a given volume of oxygen totally absorbable in the cold by mercury, silver, or iodine of potassium.

6. When pure, dry oxygen gas is enclosed in a series of glass tubes, and submitted, as above, to the action of the electric spark, and one end of each tube then broken, to find how much of the gas has been rendered capable of absorption by the alkaline iodide, it is found that for several hours the modification increases in proportion to the time of electrization, and afterwards appears to diminish, probably because the spark destroys that which it had before produced.

7. The difficulties attending the preceding experiment, induced the authors to study the action of electrized oxygen on certain absorbing substances, capable of immediately taking up the oxygen which has been subjected to the action of electricity, and thereby removing it from the decomposing action of an excess of that agent. A series of electric sparks was therefore passed through small endiometric tubes filled with oxygen, and either placed over moist mercury or a solution of iodine of potassium, or having a moist silver plate introduced into them. The oxygen was then regularly absorbed under the influence of the electric spark, and in several experiments, complete absorption took place.

8. Finally, to remove all doubts respecting the particular activity imparted to oxygen by the electric spark, the preceding experiments were repeated with sealed tubes. For this purpose, iodide of potassium and moist silver were introduced into tubes filled with pure oxygen, and the tubes were then sealed. These tubes were subjected for several days to electric action; the spark, which was very brilliant at first, became paler and paler; and, after a while nearly invisible. The ends of the tubes were then broken under water, whereupon the water rushed in and filled them com-

pletely, showing that the oxygen had been entirely absorbed in the cold by the silver and by the alkaline iodide. To render these experiments decisive, it was previously ascertained: I. That the oxygen is not absorbed by pure water, by the sides of the glass vessel, or by the platinum wires; II. That the presence of water is required, not to develop the activity of the oxygen, but to enable the active oxygen to act on the metals and the alkaline iodide; III. That the electric spark does not decompose iodide of potassium by influence.

The experiments above described may be considered as affording rigorous proof that oxygen may, by the influence of electricity, be rendered wholly absorbable at ordinary temperatures, by iodide of potassium, and by several metals—mercury and silver, for example. They likewise confirm the latest results obtained by Schönbein, Marignac, and De la Rive, respecting the nature of the so-called *ozone*, and show that electricity by acting upon oxygen, develops new properties, which did not exist in it before. The authors therefore propose to give the name of *Electrized Oxygen* to the gas thus modified by electric influence, and to abandon the term *Ozone*, which gives the idea of the transformation of the oxygen into another body.

On the preparation of pure Acetic Acid from Wood-Vinegar and Brandy-Vinegar.*

By C. Völckel.

The ordinary mode of preparing pure acetic acid from wood-vinegar, viz., by converting the latter into acetate of soda, freeing this salt from empyreumatic substances by roasting and fusion, and then decomposing it by sulphuric acid, is both tedious and expensive, in consequence of the roasting and repeated crystallizations required; consequently, the acetic acid thus obtained cannot be economically used for the preparation of pure acetate of lead, that salt being in fact obtained much more cheaply from brandy-vinegar. Various attempts have therefore been made to purify the acetic acid in wood-vinegar at a cheaper rate; and for this purpose the author proposes the following process, consisting essentially in the conversion of the crude acid into acetate of lime, and the decomposition of that salt by hydrochloric acid.

To obtain acetate of lime in a sufficient state of purity, the crude acid is saturated with lime, without previous distillation, whereupon a part of the resinous impurities separate out in combination with lime, while the rest remain in the liquid, imparting to it a dark

* Ann. Ch. Pharm. LXXXII, 49.

brown colour ; and the liquid is clarified by filtration, or by simply leaving the impurities to settle down, and afterwards evaporated in an iron pot to about one half its bulk. Hydrochloric acid is then added in such quantity, that a small sample of this liquid may distinctly redden litmus after cooling. This causes the dissolved resin to separate and collect together in the boiling liquid, so that it can easily be skimmed off—and likewise decomposes the lime-compounds of creosote and other volatile substances, which may then be expelled by further evaporation. The quantity of hydrochloric acid required for this purpose, varies of course with the constitution of the wood-vinegar, which again varies with the degree of moisture of the wood from which the acid is obtained ; but the average quantity is from 4 to 6 pounds for 150 litres (33 gallons) of the wood-vinegar. The solution of acetate of lime is then further evaporated, and ultimately dried at a high temperature, to drive off all volatile substances. The evaporation and drying may generally be performed in the same iron vessel ; but in operating on a very large scale, it is best to dry the salt on cast-iron plates : the drying requires the greatest care. The volatile empyreumatic substances adhere very tenaciously to the acetate of lime, and to the resin contained in it, and unless driven off by heat, they pass over in the subsequent distillation together with the acetic acid, and impart to it a bad odour. The drying must therefore be continued till the acetate of lime becomes inodorous, or nearly so. When thoroughly dried, it has a dirty-brown colour.

To obtain the acetic acid from this salt, it is distilled with hydrochloric acid. The distillation may be performed in a still, with copper head and leaden condensing-tube ; if the operation be conducted with proper care, neither copper nor lead is found in the distillate. The quantity of hydrochloric acid required cannot be exactly given, because the acetate of lime contains variable quantities of foreign matters, viz., resin, and chloride of calcium already formed. In general, however, from 90 to 95 parts of hydrochloric acid, of 20° Baumé, or sp. gr. 1.16, will completely decompose 100 parts of acetate of lime, without causing the distillate to be much contaminated with hydrochloric acid. In any given case, the quantity of hydrochloric acid required is easily determined by an experiment on a small scale. The apparatus may likewise be so arranged, as to allow of the subsequent addition of hydrochloric acid, in case of the quantity first put in being found insufficient. Whether the quantity introduced is sufficient, may be known by testing the distillate with nitrate of silver ; so long as mere turbidity is produced, we may be sure that the hydrochloric acid is not in excess.

The distillation of the acetic acid proceeds with ease and regularity. The acetate of lime dissolves in the hydrochloric acid, forming a dark-coloured liquid, while a quantity of coloured resin separates out. As the whole mass is liquid, the heat diffuses through it easily ; and

as the acetic acid passes over between 100° and 120° , and the acetate of lime has been already exposed in drying to a higher temperature, the distilled acid is but very slightly contaminated with empyreumatic products resulting from decomposition of the resin. Moreover, the resinous matters, being lighter than the chloride of calcium solution, float on the top, and do not form hard incrustations in the still.

The distilled acetic acid has but a very slight empyreumatic odour, which is also very different from that of crude wood-vinegar. It is perfectly colourless, and, if the hydrochloric acid has not been added in excess, gives but a slight cloud with nitrate of silver. Any yellow tint that it may exhibit, arises from particles of resin mechanically carried over; for the resin separated from the acetate of lime by the hydrochloric acid, melts as the temperature rises, and forms a fluid layer on the surface of the chloride of calcium solution, which is very apt to cause spiriting. The resin should therefore be moved as far as possible before distillation, either by skimming it off with a spoon, or by filtering through a linen cloth.

The specific gravity of the acetic acid obtained by this process, varies from 1.058 to 1.061, corresponding nearly to 8° Baumé, or 10° Beck. It contains more than 40 per cent of anhydrous acetic acid.

As, however, acetic acid of this degree of concentration is rarely used, and a somewhat weaker acid is more easily separated by distillation from the solution of chloride of calcium, it is better to add a certain quantity of water, either before or towards the end of the distillation. A good proportion is:—100 parts acetate of lime, from 90 to 95 of hydrochloric acid, and 25 of water. This gives from 95 to 100 parts of acetic acid, of 7° Baumé, or sp. gr. 1.105. In this manner 150 litres of wood-vinegar will yield 60 pounds of acetic acid of this strength.

The acetic acid thus obtained; may be still further purified by mixing it with a small quantity of carbonate of soda, and distilling it again. The acid which passes over is free from hydrochloric acid and perfectly colourless, but still retains a slight empyreumatic odour. But even this may be removed by distilling it with 2 or 3 per cent of bichromate of potash instead of carbonate of soda.

Acetic acid purified with bichromate of potash is, in fact, undistinguishable from that which is obtained from pure acetate of soda by distillation with sulphuric acid, or from pure acetate of lime with hydrochloric acid. It does not exhibit the slightest colour when heated with strong sulphuric acid, nor does it reduce the smallest quantity of silver when boiled with nitrate of silver and ammonia. When saturated with oxide of lead, it also yields a colourless salt, the analysis of which agrees perfectly with that of pure acetate of lead. Peroxide of manganese may also be used for the purification, instead of bichromate of potash; but the acid thus purified, gives, after a while, a slight turbidity with nitrate of silver; any empyreu-

matic odour that it may retain may be removed by digestion with purified animal charcoal.

As the acetic acid can be so easily freed from hydrochloric acid, a slight excess of the latter during distillation is not injurious; on the contrary, the presence of a small quantity of hydrochloric acid is very useful for the purification of the acetic acid with manganese or bichromate of potash.

The rectification of acetic acid with bichromate of potash or with manganese, may be very well conducted in a copper still, with leaden condensing tube: the acid thus prepared can only be contaminated with a small quantity of acetate of lead. If, however, access of air be prevented* during the distillation, this impurity will be confined to the first and last portions of the distillate; and by collecting these apart, to be used for the preparation of acetate of lead, the greater part of the acid may be obtained free from lead. With these precautions, the use of glass or silver heads and condensing tubes may be dispensed with.

The preparation of acetic acid by the method just described, may be rendered simpler by subjecting the wood-vinegar to a previous distillation, and thereby removing the greater part of the resin. But this previous distillation entails increased expense for labour and fuel, because the same liquid must be twice evaporated; moreover, part of the acetic acid remains with the tar in the still. On the small scale the loss thus occasioned is unimportant; but in a large manufactory, it would amount to something considerable in the course of a year.

The expense occasioned by previous distillation of the wood-vinegar may be avoided by the use of a compound still. The vapour of the wood-vinegar, instead of being condensed immediately, is made to pass into a copper receiver containing the quantity of lime required to saturate the acid, which is thereby completely absorbed. If the copper receiver be surrounded by some substance which is a slow conductor of heat, but little aqueous vapour condenses in it. This vapour may be advantageously used to evaporate a solution of lime resulting from a previous operation. This process is, however, more complicated, and does not yield more acetic acid than the simpler one first described.

The method here recommended is much cheaper, and yields a much purer product than the ordinary method of distilling impure acetate of lime with sulphuric acid. Moreover, by the addition of hydrochloric acid during the evaporation of the impure acetate, the volatile, slightly acid bodies contained in the wood-vinegar, are removed much more easily than by the use of a solution of chloride of calcium (Schnedermann), or by roasting the impure acetate of

* The entrance of air into the condensing-tube may be prevented by closing the end of the tube with a cork, through which is inserted a glass tube, bent in the form of an S.

lime, either alone or with hydrate of lime (Kestner, Schwarz). In the latter process, even if it attains the desired end, a considerable loss is incurred from decomposition of the acetate of lime, inasmuch as that substance, from its infusibility, does not admit of any exact regulation of the heat.

The use of hydrochloric instead of sulphuric acid, in the decomposition of the acetate of lime, has this great advantage, that the presence of resins, colouring matter, &c., in the acetate of lime, does no harm, provided the acetate has been sufficiently heated to drive off these free volatile substances. When, on the contrary, sulphuric acid is used, the acetic acid produced always has a bad odour, is saturated with sulphurous acid, and contaminated by various products arising from the decomposition of the resins at an elevated temperature. Moreover, the sulphate of lime forms a hard crust at the bottom of the still, and in distilling on the large scale, the bottom of the still must be heated red-hot to drive out all the acetic acid. The last portions of acid that pass over are often turbid from the presence of separated sulphur; and the odour of sulphuretted hydrogen becomes perceptible, that substance arising from reduction of the sulphate of lime to sulphide of calcium at the bottom of the vessel: from this cause, cast-iron stills soon become corroded.

The low price at which pure acetic acid may be obtained by the method above described, will probably lead to a more extended use of it in dyeing and calico printing. The acid thus obtained may, likewise be advantageously used in the preparation of acetates, especially of acetate of lead.

Pure Acetic Acid from Brandy-Vinegar. A similar process may be adopted for the preparation of pure acetic acid from brandy-vinegar; the process, however, is simpler, inasmuch as brandy-vinegar is much less impure than wood-vinegar.

Strong brandy-vinegar (the best for this purpose is that which contains from 12 to 15 parts of anhydrous acetic acid—a proportion which is obtained in some manufactories by a process at present not much known) is saturated with lime; and the turbid and coloured solution is strained through a linen cloth, and evaporated to dryness in an iron vessel. The dried salt is perfectly white, the colouring matters previously contained in the solution having been for the most part destroyed by the oxidizing action of the air.

The decomposition of the acetate of lime is effected by hydrochloric acid in the manner already described, excepting that, the acetate of lime being less mixed with foreign matter than that obtained from wood-vinegar, a larger proportion of hydrochloric acid is required for its decomposition, viz., about 130 parts of acid to 100 parts of the lime-salt.

The final purification of the acid may be effected by either of the methods above described.

On Cenantbic Ether and Cenantbic Acid.*

By W. Delffs.

Cenantbic ether was first investigated in 1836 by Liebig and Pelouze,† who assigned to it the formula



relying, in the calculation of their analyses, chiefly on the vapour-density; this they found to be 10·508, a result agreeing very closely with calculation, assuming that the vapour was condensed to *two* volumes. At present, however, organic compounds in general, and the ethers more especially, are regarded as condensed to 4 volumes, so that cenantbic ether, considered as above, presents an anomaly which throws some doubt on the correctness of the calculation, more especially as compounds of purely organic origin rarely have so high a vapour-density as that just quoted. Moreover, the formula $\text{C}^{14} \text{H}^{13} \text{O}^2$ can scarcely be the correct expression of the composition of anhydrous cenantbic acid; first, because it would require us to suppose that in the lead and silver-salts, 3 atoms of acid are united with 2 atoms of base, which is very unusual in organic acids; and secondly, because the occurrence of an acid with only 2 atoms of oxygen is scarcely to be found in the whole range of organic chemistry, certainly not among the *fatty* acids. Lastly, the relation between the composition and boiling points of organic compounds shows that the composition of cenantbic ether must be different from that which is given by Liebig and Pelouze. These considerations induced the author to submit this body to a further examination, which led to the following results.

1. *Cenantbic Ether*.—The substance employed had a yellowish colour, and feebly acid reaction. When subjected to fractional distillation, it began to boil at 240° C. The temperature then rose steadily to 246°, where it began to be stationary. The receiver was then changed, and the distillation continued for two hours, during which time the thermometer did not rise above 250°. The liquid which passed over during this interval, amounting to nearly the fourth part of the crude ether, was used in the following experiments. It was perfectly colourless, but still slightly acid; it was therefore washed with solution of carbonate of soda, dried by chloride of calcium, and rectified.

When the ether thus purified was used for the determination of the boiling-point, it again acquired a yellowish tinge; and when boiled over a spirit-lamp, either with or without platinum wire, exhibited a very peculiar phenomenon, bubbles of vapour bursting from the

* Pogg. Ann. LXXXIV, 505.

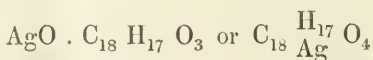
† Ibid. XLI, 571.

liquid from time to time, with a noise as if the retort were cracking, and giving rise each time to a visible cloud of condensed vapour. This phenomenon was not exhibited when the ether was heated on a sand-bath. It differed from the well-known sudden agitation which many liquids present in boiling, by not causing any perceptible interruption to the quiet progress of the ebullition. After the ether had been rectified a second time, when a yellowish residue again remained, this effect was but very slightly exhibited, though the boiling-point differed from the former by scarcely half a degree.

The ether thus purified was colourless, had a pleasant vinous odour, and a taste, slight at first, but afterwards irritating to the throat, Sp. gr. = 0.8725 at 15.5° C. Index of refraction = 1.414 at 13.5° C. Boiling-point very constant at 224°, under a pressure of 27" 8'''·1, with the mercury at a temperature of 14°.

The analysis of the ether with oxide of copper gave, carbon 70.5 and 70.6 per cent; hydrogen 11.8, numbers agreeing very closely with the formula $C^{22} H^{22} O^4$. The vapour-density was found by experiment to be 7.042; calculation from the formula, $C^{22} H^{22} O^4$, gives 6.449. The difference is somewhat greater than is desirable, but is sufficiently accounted for by the impossibility of heating the vapour to the necessary temperature above the boiling-point without decomposing it.

Cenanthic Acid.—Cenanthic ether is rapidly decomposed by heating it with caustic potash; and on subsequently adding hydrochloric acid to the solution, cenanthic acid separates in the form of a slightly yellowish oil, which solidifies on cooling, in a snow-white mass, showing scarcely any traces of crystallization. It is readily dissolved by alcohol, even in the cold, and in almost every proportion by ether; from the alcoholic solution it separates by spontaneous evaporation as a crystalline mass. When pure, it is perfectly destitute of taste and smell, and melts even with the heat of the hand. The accurate determination of the melting-point is difficult, as the acid passes into a buttery state before melting, but it is certainly below 25° C. The acid dissolves easily in ammonia, forming a solution which dries up, even on spontaneous evaporation, to a greasy soap, which does not again form a clear solution in water. The solution of the ammoniacal salt, made as neutral as possible, formed, with nitrate of silver, a white curdy precipitate, which did not dissolve perceptibly in boiling water. This salt, when thoroughly washed and dried, gave, on analysis, numbers corresponding with the formula:



The composition of the hydrated acid must therefore be $C_{18} H_{18} O_4$, a formula with which the analysis made by Liebig and Pelouze agrees

sufficiently well, when their results are calculated according to the atomic weight of carbon at present adopted.

From this it appears that œnanthic acid is identical in composition with pelargonic acid as analyzed by Redtenbacher and Pless.* The two acids appear also to be similar in properties, so far, at least, as Redtenbacher has determined those of pelargonic acid. The identity in composition was likewise confirmed by the analysis of the baryta-salt of œnanthic acid. Pelargonate of baryta is said by Redtenbacher to resemble the crystals of cholesterin. Such a resemblance was not observed in the œnanthate; but its absence is of little importance, as the author has, on other occasions, observed considerable differences in the appearance of crystals of butyrate of baryta, though they are always, as Lerch† states, perfectly anhydrous.

There is one point in Liebig and Pelouze's investigation which must for the present be left undecided, viz., the change which œnanthic acid undergoes by distillation. This the author was unable to investigate properly, for want of material; but the portions which passed over at a high temperature appeared to contain an acid having a higher equivalent (capric acid?).

In a note appended to this paper, the author states that the conversion of organic baryta-salts into carbonate of baryta by ignition in a flat platinum dish, affords a very convenient mode of ascertaining the atomic weight of an organic acid.

**On Sorbine, a new saccharine substance, extracted from the
berries of the Mountain Ash.‡**

By J. Pelouze.

The berries of the mountain ash contain, amongst other substances, malic acid, malate of lime, and grape-sugar; their great acidity forbids the supposition that they contain ordinary cane-sugar; but Pelouze has succeeded in obtaining from them a sugar, differing in many essential properties from any of the sugars previously known.

The berries, gathered towards the end of September, were crushed and squeezed through linen. The juice thereby obtained was left to itself in earthen vessels for thirteen or fourteen months, during which time it yielded deposits and vegetations which were not examined. The liquid, which at length clarified spontaneously, was decanted, and then evaporated at a gentle heat to the consistence of a thick syrup. This syrup deposited a quantity of dark-brown

* Ann. Ch. Pharm. LIX, 52.

† Ibid. XLIX, 216.

‡ Ann Ch. Phys. [3], XXXV, 223; J. Pharm. [3], XXI, 321.

crystals which were completely decolourized by treating them twice with animal charcoal. By successive concentration of the mother-liquid, fresh quantities of crystals were obtained and purified in a similar manner.

The crystals thus contained consist of a new substance, to which the author gives the name of SORBINE. By analysis they yielded in 100 parts: carbon, 40.00; hydrogen, 6.66; oxygen, 53.34, agreeing with the empirical formula CHO. The numbers have been confirmed by MM. Cahours and Cloez, to whom a specimen was sent for analysis.

To determine the rational formula, a solution of acetate of lead, slightly ammoniacal, was added to a solution of sorbine in excess; a white precipitate was then formed, which, when washed and dried, yielded by analysis numbers which agreed nearly with the formula $4 \text{ PbO} \cdot \text{C}_{12} \text{ H}_9 \text{ O}_9$. Hence it would appear that the formula of aqueous sorbine is:



Sorbine combines with common salt, forming crystals which, when examined by the microscope, appear to be cubic.

Sorbine is colourless, and has a pure sweet taste, which cannot be distinguished from that of cane-sugar. The crystals are perfectly transparent, hard, and grate between the teeth like sugar-candy. They are rectangular octohedrons, belonging to the right prismatic system. Their density at 15° is 1.654. Water dissolves more than twice its weight of them; boiling alcohol, on the contrary, dissolves but a very small quantity, which it deposits again on cooling, in octohedral crystals, similar to those which are obtained from the aqueous solution.

A concentrated solution of sorbine resembles the syrup of ordinary sugar. Its density, determined upon a liquid which was not quite pure, was 1.372 at 15° . Both sorbine itself, and the syrup which it forms with water, are somewhat denser than cane-sugar and its syrup.

Sorbine dissolved in water and mixed with yeast showed no signs of fermentation, even after twenty-four hours' exposure to a temperature of 20° – 30° C. Dilute sulphuric acid produces no change in it, and does not render it fermentable.

Strong sulphuric acid attacks sorbine rapidly, first colouring it reddish-yellow, and then, under the influence of a gentle heat, changing it into a black carbonaceous substance, which the author has not yet examined. When nitric acid, either concentrated or diluted with half its weight of water, is heated with sorbine, abundance of red fumes are given off, and oxalic acid is produced, equal in weight to more than half the sorbine used; in fact the action is perfectly

similar to that which takes place with cane-sugar. The author has not yet determined whether any intermediate product is formed.

A solution of sorbine heated with alkalis acquires a deep yellow colour, and exhales an odour of caramel. Water containing $\frac{1}{1000}$ of sorbine becomes perceptibly yellow when heated with potash. Sorbine dissolves a considerable quantity of lime. The filtered liquid turns yellow when heated, depositing a flocculent precipitate, and giving off a distinct odour of caramel. Baryta acts in the same manner as lime. Oxide of lead also dissolves in a hot solution of sorbine, forming a yellow liquid, which has the odour of burnt sugar.

Sorbine yields no turbidity with subacetate of lead, but on the addition of ammonia, a white precipitate is formed.

Sorbine dissolves hydrated protoxide of copper, forming a deep blue solution, which gradually deposits a red precipitate of the suboxide. Tartrate of copper and potash is also reduced by sorbine, either hot or cold.

Sorbine, strongly heated on platinum-foil, or thrown upon a hot coal, behaves like common sugar, fusing, turning yellow, exhaling a strong odour of caramel, and leaving a bulky charcoal. But when it is carefully heated for some time to a temperature between 150° and 180° C., it gives off vapour of water slightly acid, and is converted into a new acid, which remains in the form of a deep-red body.

To obtain this acid pure, the residue is dissolved in potash or ammonia, the solution filtered, and supersaturated with dilute hydrochloric acid. The acid is then precipitated in deep-red flakes, which are washed with distilled water, and then dried in a stove at a temperature between 120° and 150° . The author distinguishes this new acid by the name of **SORBIC ACID**.

Sorbic acid is amorphous, of a very deep-red colour, insoluble in water, alcohol, and weak acids, but very soluble in potash, soda, and ammonia, with which it forms solutions having a very rich sepia colour. A mere trace of sorbic acid is sufficient to impart a sensible colour to an alkaline liquid.

The soluble salts of lime, baryta, alumina, iron, tin, gold, and platinum, form with soluble sorbates, bulky precipitates, exhibiting reddish-yellow colours of various degrees of intensity. Sulphate of copper yields a yellowish-green precipitate, soluble in excess of ammonia, to which it imparts a very deep-green colour.

Sorbic acid is found by analysis to contain: carbon, 57.96; hydrogen, 5.51; oxygen, 36.53; and the sorbate of lead consists of 51.35 oxide of lead with 48.65 sorbic acid. Hence if the formula of sorbic acid be $C^{32} H^{18} O^{15}$, that of the lead-salt will be $3PbO \cdot C^{32} H^{18} O^{15}$.

Sorbine acts upon polarized light; when dissolved in water or in acids, it turns the plane of polarization *to the left*; in this respect

it differs from other crystallizable sugars, all of which turn the plane of polarization *to the right*.

On the Constitution of Citric Acid.*

By L. Pebal.

The author commences his paper with a sketch of the principal views which have been entertained respecting the constitution of citric acid, dwelling chiefly on those of Berzelius and Liebig. Berzelius† regarded citric acid as monobasic, assigning to the acid contained in the neutral citrates the composition, $C_4 H_2 O_4$. This view rested chiefly on an experiment, from which it appeared that the crystals obtained by cooling a solution of citric acid saturated at $100^\circ C.$ had the composition $HO \cdot C_4 H_2 O_4$, and did not give off any water when heated to 100° . On the contrary, the crystals obtained from a solution saturated at ordinary temperatures, lost at 100° a quantity of water, which, if their composition were denoted by the formula, $HO \cdot C_6 H_3 O_6 + Aq.$ ‡ would amount to one equivalent; hence, the last-mentioned crystals, if referred to the atomic weight of citric acid first given, would contain, after dehydration, $\frac{1}{3}$ eq. of water less than the crystals obtained from the hot solution, likewise dried at 100° .

Liebig,§ on the contrary, regards the acid as terbasic, and expresses the several compounds just mentioned by the following formulæ:

- $3 HO \cdot C_{12} H_5 O_{11} + 2 Aq =$ acid crystallized from a solution saturated at ordinary temperatures.
 $3 HO \cdot C_{12} H_5 O_{11} + Aq =$ crystals obtained by Berzelius from a hot saturated solution.
 $3 HO \cdot C_{12} H_5 O_{11} =$ the first compound dried at $100^\circ C.$

The second formula is evidently equivalent in numbers to that of Berzelius, $HO \cdot C_{12} H_2 O_4$. taken three times; if, however, it be correct, one-fourth of the water, that namely which is supposed to exist as water of crystallization, should go off at $100^\circ C.$, whereas, according to Berzelius, it does not. Marchand,|| however, found that the crystals obtained from a hot saturated solution, gave results agreeing with the formula $HO \cdot C_4 H_2 O_4$, only when analyzed immediately after removal from the mother-liquor; but that when they were left for a while in vacuo over sulphuric acid, they gave off 2.2 per cent of water without losing their transparency, and their composition then agreed exactly with that of ordinary citric acid, dried at 100° , viz.,

* Ann. Ch. Pharm. LXXXII, 78.

† Pogg. Ann. XXVII, 281; Ann. Ch. Pharm. V, 129, 134, 137.

‡ Prout. Pogg. Ann. XII, 271.

§ Compt. rend. V, 863; Ann. Ch. Pharm. XXVI, 113.

|| J. pr. Chem. XXIII, 60.

$3 \text{HO} \cdot \text{C}_{12} \text{H}_5 \text{O}_{11}$. The excess of water which the crystals contain on being first separated from the liquid can, therefore, only be regarded as adhering moisture. This result has been completely confirmed by the experiments of Pebal.

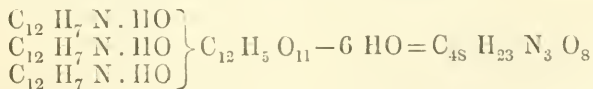
Liebig's view of the constitution of citric acid is likewise confirmed by the formula of citric ether as determined by Dumas,* viz: $3 \text{AcO} \cdot \text{C}_{12} \text{H}_5 \text{O}_{11}$, and by those of the citrates of methyl, determined by Evre,† viz., $3 \text{MeO} \cdot \text{C}_{12} \text{H}_5 \text{O}_{11}$, and $2 \text{MeO} \cdot \text{HO} \cdot \text{C}_{12} \text{H}_5 \text{O}_{11}$.

The following experiments of Pebal, on the anilides of citric acid, likewise tend to establish the terbasic formula.

Crystallized citric acid in the state of powder, was mixed with a slight excess of aniline containing water (*i.e.*, in the state in which it separates as an oily body under water) and heated in a glass flask to $140^\circ - 150^\circ \text{C}$. till the emission of vapour-bubbles began to slacken. On cooling, it solidified to a brown-red glass, which was exhausted with boiling water; and the residue, which, meanwhile, had assumed the form of a pale yellow powder, was dried, dissolved in strong alcohol, and decolourized with animal charcoal.

The aqueous extract, after evaporation, deposited a small quantity of an acid crystalline mass consisting of citromonanilic acid, a substance to be hereafter described. The alcoholic solution yielded crystals of three different substances, two of which had the form of thin prisms, and the third that of hexagonal tables. Of the two kinds of prismatic crystals, the one became dull and opaque when left to stand over sulphuric acid covered by a bell-jar, while the others remained unaltered under the same circumstances. The largest portion of these crystals consisted of:

Citronanilide, $\text{C}_{48} \text{H}_{23} \text{N}_3 \text{O}_8$.—This substance is insoluble or very sparingly soluble in water; sparingly, also, in boiling alcohol, from which it crystallizes by spontaneous evaporation in flat, colourless, rectangularly truncated prisms, attaining the length of about 3 millimetres. They are sometimes very slender, generally arranged in concentric masses, longitudinally striated, and have a mother-of-pearl lustre. Their solution has no action on vegetable colours. Strong solution of potash or ammonia does not decompose the crystals, and may, therefore, be used to purify them from the six-sided tables, which are dissolved by the strong alkali. This substance may be regarded as terbasic citrate of aniline *minus* 6 HO.



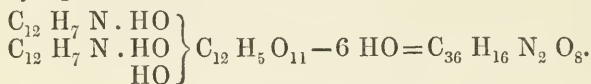
Citrobianil, $\text{C}_{36} \text{H}_{16} \text{N}_2 \text{O}_8$.—The six-sided laminæ already spoken of. Probably the best mode of preparing this compound by

* Compt. rend. VIII, 528.

* Ibid. XXI, 1411.

itself, would be to mix citric acid with aniline in the proportion required to form a bibasic salt, and heat the mixture to 150° C. as long as any perceptible evolution of hydrogen took place. The coloured crystals may be purified by treating their alcoholic solution with animal charcoal and recrystallizing. The solution of the pure substance, which does not alter the colour of litmus-paper, yields, by spontaneous evaporation, six-sided laminæ or tables of the diameter of about 5 millimetres. They are transparent, and dissolve very sparingly in water, but easily in boiling alcohol. By boiling with strong ammonia, they are converted into citrobianilic acid. The crystals, after drying in the air, do not lose weight by being kept over sulphuric acid.

Citrobianil may be supposed to be formed from bibasic citrate of aniline by separation of 6 HO :

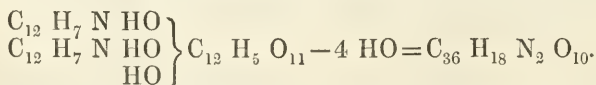


The four-sided, obliquely-truncated needles, which were obtained simultaneously with the citronanilide and citrobianil, and distinguished by the property of efflorescing when placed over sulphuric acid, lost at 100° about 1.08 per cent of their weight after drying in the air. They were found to contain 66.71 per cent carbon and 5.0 per cent. hydrogen, numbers which agree exactly with the composition of citrobianil; but the quantity obtained was not sufficient to enable the author to speak positively as to their identity.

Citrobianilic Acid, $\text{C}_{36} \text{H}_{18} \text{N}_2 \text{O}_{10}$ or $\text{HO} \cdot \text{C}_{36} \text{H}_{17} \text{N}_2 \text{O}_9$.—When citrobianil is boiled with strong ammonia, it gradually dissolves, and is converted into the ammonia-salt of citrobianilic acid. The solution mixed with hydrochloric acid, deposits the acid in the form of a curdy precipitate, which is soluble in alcohol; and the alcoholic solution, which reddens litmus, yields the acid in soft silky needles radiating from several centres; they dissolve readily in alcohol, but sparingly in water. The acid melts at about 153° , giving off water and being converted into citrobianil. It may indeed be regarded as formed from citrobianil by taking up 2 eq. water :



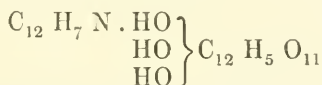
and its composition is that of bibasic citrate of aniline, *minus* 4 HO.



Citrobianilate of Silver, $\text{AgO} \cdot \text{C}_{36} \text{H}_{17} \text{N}_2 \text{O}_9$, was obtained by mixing a neutral solution of the acid in ammonia with nitrate of silver ;

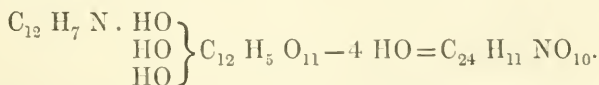
it formed a white precipitate. The *Baryta-salt*, $\text{Ba O}, \text{C}_{36} \text{H}_{17} \text{N}_2 \text{O}_9$, was obtained, in a similar manner, by double decomposition, in the form of a white, amorphous precipitate. The *Aniline-salt*, $\text{C}_{12} \text{H}_7 \text{N} \cdot \text{HO} \cdot \text{C}_{36} \text{H}_7 \text{N}_2 \text{O}_9$, was obtained by digesting the acid at a moderate heat with aqueous aniline. On evaporating the solution, the salt was deposited in colourless, transparent laminae, which suffered very little diminution in weight by drying over sulphuric acid. The composition of these salts show that the acid is monobasic.

Monobasic Citrate of Aniline.—An alcoholic solution of citric acid was mixed with the proper quantity of aniline containing a little water, and the mixture left in vacuo over sulphuric acid till it dried up to a viscid, brown-red mass. After some time, crystals began to form in it, and ultimately filled the whole mass. The whole was then triturated with a small quantity of alcohol, the liquid pressed through linen, the solid residue dissolved in strong alcohol, and the solution left to evaporate over sulphuric acid. The salt was then obtained in fine needles united into geodes. They fuse at 100° , dissolve readily in alcohol, and still more readily in water. Sometimes, after the mother-liquor has been poured off, the fine needles form a kind of frothy mass. The composition of this salt may be expressed by the formula:



The two other aniline-salts show no tendency to crystallize.

Monobasic Citromonanilic Acid, $\text{C}_{24} \text{H}_{11} \text{NO}_{10}$.—When the salt just described is fused at a temperature of 140° – 150° , water escapes, and the residual mass solidifies, partly while hot and partly on cooling, to a crystalline body, which dissolves very easily in water, provided an excess of aniline has been avoided, and separates by spontaneous evaporation, partly in crystalline globules, but more abundantly in the form of warty crusts consisting of small prisms. They may be rendered colourless by treatment with animal charcoal and recrystallization. They are likewise easily dissolved by alcohol; their solutions redden litmus-paper. The acid may be regarded as monobasic citrate of aniline *minus* 4 HO:

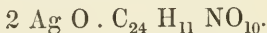


Silver-salt, $\text{AgO} \cdot \text{C}_{24} \text{H}_{10} \text{NO}_9$.—An alcoholic solution of the acid neutralized with ammonia, gave a white precipitate with nitrate of silver. The liquid separated from this precipitate yielded, after a while, crystalline globules, which, when freed from a small quantity

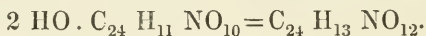
of pulverulent matter adhering to them, were found to have the composition above given.

Aniline-salt, $C_{12} H_7 N . HO . C_{24} H_{10} NO_9$.—Formed by saturating the aqueous solution of the acid with aniline. Spherical geodes, easily soluble in alcohol.

Silver-salt of Bibasic Citromonanilic Acid.—The white precipitate obtained in the preparation of the silver-salt of the monobasic acid. Its composition is expressed by the formula :



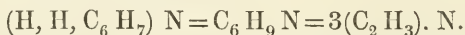
It was found impossible to obtain the hydrate of this acid, on account of its strong tendency to decompose. Its formula would be



On the occurrence of Trimethylamine in Herring-brine.*

By Dr. Hofmann.

In the course of some observations on the ammonias of the methyl-series,† Dr. Hofmann has suggested that the base described by Wertheim under the name of *Cenylamine*, or *Propylamine*, may be identical with trimethylamine :



The interesting observation likewise made by Wertheim, that the so-called propylamine exists in considerable quantity in herring-brine, has afforded an opportunity of putting this question to the test of experiment. At Dr. Hofmann's suggestion, the subject has been examined by Mr. Henry Winkles, from whose experiments it appears that the principal constituent of a mixture of bases contained in herring-brine is actually *Trimethylamine*. The base was identified both by comparison with trimethylamine synthetically prepared, and by its behaviour with iodide of methyl. With the latter it instantly solidified into a crystalline mass of iodide of tetramethylammonium.

From these experiments it seems doubtful whether the true *Propylamine* has yet been obtained. It would also be as well to examine by experiment whether *Petinine* is really entitled to the name of *Butylamine*. This question might be easily decided by the behaviour of petinine with iodide of methyl or iodide of ethyl.

* Ann. Ch. Pharm. LXXXIII, 116.

† Ibid. LXXIX, 29.

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

XXIII.—*On the Action of Iodine upon Phosphorus.*

By B. C. BRODIE, F.R.S.,

SECRETARY OF THE CHEMICAL SOCIETY.

The law of the formation of certain elemental bodies, which I have given in a former paper* suggests the probable cause of their allotropic differences. For if it be proved that the formation of the element is a chemical synthesis of the same nature as the formation of a compound substance, we are enabled to transfer to the element those ideas of *form*, by which we most reasonably explain isomeric differences, and to comprehend that, in their case also, two or more substances may exist, identical in their ultimate chemical constitution, yet differing in the arrangement of their particles.

Considering how this view might be brought to the test of experiment, it occurred to me that there was a certain mode of effecting the isomeric transformation of compound substances of which as yet there was no example in the case of the elemental bodies, and which appears to me essentially to depend upon the peculiar chemical nature of the change produced. I speak of that continuous chemical action by which sulphuric acid converts aldehyde into a body isomeric with it, but of triple its atomic weight, and by which the same acid transforms oil of turpentine into the remarkable series of isomeric hydrocarbons investigated by Deville.

* Chem. Soc. Qu. J. IV, 194.

A fact which had been observed in the action of iodine upon phosphorus seemed to indicate what I sought. In various experiments in which these substances had been brought together, a certain red body had been observed, resembling the allotropic phosphorus, the origin and true nature of which was unexplained. Thus, for example, Berzelius* remarks that if less be taken than six parts of iodine to one of phosphorus, the phosphorus separated is in the state either of oxide or of the modification produced by sunlight. Recently, Mr. Corenwinder,† in his investigation on the iodides of phosphorus, observed that when iodine and phosphorus were dissolved in bisulphide of carbon, if more than a certain proportion of phosphorus was employed, a matter of the same appearance was produced on evaporating the solution.

The action of iodine upon phosphorus is, as is well known, very violent; therefore the better to investigate the nature of the experiment I dissolved the iodine and phosphorus in bisulphide of carbon, evaporated the solution to dryness in the method above mentioned, and carefully washed out the residue thus obtained with bisulphide. This residue has much the appearance of the allotropic modification; but on examining its nature more closely, I discovered that a large proportion of iodine was retained by the phosphorus in a form insoluble in bisulphide of carbon. It was evident that some peculiar iodide of phosphorus was formed. My efforts, however, to separate any substance in a pure state, or indeed to obtain in this manner any constant results whatever, failed.

It occurred to me that were I able to cause the formation of this iodide to take place in the fluid itself, it might separate free from the other matter which accompanied it, and in a condition in which it could be readily washed and purified. At the usual boiling-point of the bisulphide, the substance is not formed, but it was probable that at a higher temperature it might be produced. To make this experiment I placed the solution of iodine and phosphorus in bisulphide in tubes hermetically sealed, which I heated in a water-bath to 100° C. After a short time, a copious red deposit appeared on the sides of the tube. I used at first what appeared to me a great excess of phosphorus, 10 or 12 equivalents to 1 of iodine. The whole of the iodine was retained in the red substance. The filtered fluid contained unaltered phosphorus. The substance was dried in a current of hydrogen, and the phosphorus determined as pyrophosphate of magnesia. The

* *Traité de Chimie*, I, 247.

† *Ann. Ch. Phys.* [3] XXX, 242.

results which I obtained were very constant, different tubes gave very nearly the same amount of phosphorus, and I was inclined to believe that I had obtained the iodide in question, pure. But closer examination proved that when the circumstances were sufficiently modified, very great variation took place in the results, and I arrived at length at the fact, that the amount of red phosphorus in the precipitate, increased directly with the proportion of phosphorus employed in the experiment. Thus, for example, from a solution containing 12 equivalents of phosphorus to 1 of iodine, a substance was formed containing 68 per cent of phosphorus. When the proportions were as 10 equivalents of phosphorus to 1 of iodine, the substance contained 66 per cent. When as 4 equivalents to 1, 60 per cent. When as $2\frac{1}{2}$ to 1, 58 per cent. When as 1 to 1, 54.5 per cent of phosphorus. These proportions vary from about 1 equivalent of iodine to 8 of phosphorus, to 1 equivalent of iodine to 5 of phosphorus. The experiments are not perfectly comparable with each other, for there is another cause of variation, namely, *time*, which should be strictly taken into account. This, however, under the circumstances under which the experiments were made, has, I have ascertained, but a very small effect compared with the influence of mass. The inference which I draw from these experiments is, not that this substance is a new sort of chemical combination in varying proportions, but that some definite iodide of phosphorus is present, accompanied by proportions of the allotropic phosphorus, which vary according to the circumstances I have mentioned, and from which by the similarity of its properties it cannot be separated. I was very desirous of isolating this iodide, but my attempts to effect this have hitherto failed.

Cold water does not act on this substance; by boiling water it is slowly decomposed. In caustic potash solution, phosphide of hydrogen is evolved, and the whole substance ultimately destroyed; but boiled with a solution of carbonate of soda, the iodide is decomposed with but little action on the phosphorus. By far the greater part of the iodine can readily be thus removed, but slight traces so adhere to the phosphorus, that I have never succeeded in absolutely separating it. A preparation thus made gave 94.9 per cent of phosphorus determined as pyrophosphate of magnesia.

Heated in a small tube, the substance appeared to distil unaltered. Like arsenic, it sublimed without melting, and presented the very peculiar appearance of that metal on sublimation, which is not easy to describe, separating from the sides of the tube in thin leaves. The sublimate was black, and of a semi-metallic lustre. Making the experiment on a larger scale, I found, however, that it was by no

means unaltered; for the distilled substance washed with cold water gave a large quantity of hydriodic acid.

To examine the final result of this decomposition, several grammes of a substance which had been analysed were distilled from one end of a combustion tube to the other, the centre of the tube being filled with small pieces of pumice, heated red-hot with charcoal. A very high temperature is required for the distillation. The distilled substance, when cold, was broken from the sides of the tube, and at once extracted with bisulphide of carbon. The bisulphide dissolved a large quantity of the ordinary iodide of phosphorus, probably I_2P , which, on evaporation, crystallized from the solution, and also a portion of ordinary phosphorus. The substance was now analysed. I did not bring it in contact with water, lest oxygen should enter into the substance at the moment of the decomposition of the iodide. Before the distillation, the body contained 67·3 per cent of phosphorus; it now contained 89·5 per cent. The experiment was repeated with the same substance. After this second distillation, it contained 95·5 per cent of phosphorus. It was plain that the effect of the distillation was to decompose the body with formation of ordinary iodide of phosphorus and the allotropic phosphorus itself.

These facts gave the key to the true nature of this change. It became evident to me that it belonged to that class of infinite chemical actions to which I have before alluded. This is further proved by the following experiments.

A tube about half an inch wide, containing 16·9 grains of ordinary phosphorus, was filled with carbonic acid, and closed by a cork, and then placed in warm water at a temperature of about $40^{\circ}C$., so as just to melt the phosphorus. It was removed from the water, and 0·64 grains of iodine, being 1 equivalent of iodine to 100 equivalents of phosphorus, gradually projected into it. The iodine dissolved in the phosphorus, colouring it slightly red. The tube, closed by a cork, was heated gradually in an oil-bath, and examined as the temperature rose. At 100° , the colour became deep red; at 120° to 130° , a scarlet powder was deposited on the sides of the tube. Before 140° , the mass was quite solid. At about 200° , a sharp explosion took place with a loud report, driving the cork from the tube. The vapour inflamed at the mouth of the tube, but no portion of the substance was driven off. An intense heat had evidently been evolved. The substance was broken in various places, and traces of ordinary phosphorus distilled on the sides of the tube. Nearly the whole of the phosphorus used had passed into the allotropic modification.

To determine the quantity of phosphorus which could thus be converted by a given quantity of iodine, I made the following experiments in the manner just described, and after the action, broke out the substance from the tube, washed it carefully with bisulphide of carbon, dried it in a current of hydrogen, and weighed it. The whole of the iodine was always retained in the insoluble form. The amount of iodine used was deducted from the substance obtained, and the difference considered as the phosphorus converted. This method is of course rough, but it gives results sufficiently accurate to show the general law of the action. About 10 or 12 grains of phosphorus were usually employed in each experiment. In two experiments, strictly comparable, heated for the same time at the same temperature, in which 1 equivalent of iodine acted on 100 equivalents of phosphorus, 1 part by weight of iodine converted 19·85 and 19·45 parts of phosphorus, or 1 equivalent of iodine converted 78 equivalents of phosphorus. In four other experiments comparable with each other, in two of which 1 equivalent of iodine and 100 equivalents of phosphorus, and in the other two, 1 equivalent of iodine and 200 equivalents of phosphorus were employed. The results were as follows: in the two former, 1 part of iodine converted 21·6 and 24·0 of phosphorus, or 1 equivalent of iodine converted about 94 equivalents of phosphorus; in the two latter, 1 part of iodine converted 29·32 and 27·91 parts of phosphorus, or 1 equivalent converted about 115 equivalents of phosphorus. In two other experiments made with 500 equivalents and 1000 equivalents of phosphorus, in the latter of which only about 0·008 grms. of iodine acted on 20 grms. of phosphorus, one part of iodine converted 64·8 and 99·62 parts of phosphorus, being as 1 to 257 and 395 equivalents. The greater part of the change is evidently effected at the moment when the principal evolution of heat takes place. But, as in the experiments with bisulphide, the quantity converted varies with the time, and there is every reason to believe, that taking this into consideration, the effect produced by the iodine is absolutely unlimited.

The change thus produced may be exhibited in various ways. When phosphorus is melted at the bottom of a flask filled with carbonic acid by a stream constantly passing through it, and iodine projected in very small quantities on the phosphorus by means of a long tube inserted in the cork and reaching nearly to the bottom of the flask, with both extremities open, a violent action takes place, attended with the production of intense heat. After the experiment, the substance appears as a very hard semi-metallic black mass, giving

a red powder. In this way, at least 30 grms. of phosphorus may be operated upon with safety.

The same experiment may be made under certain liquids which do not act upon the iodide. Water cannot be used, but the experiment succeeds with very concentrated hydrochloric acid. A small quantity of phosphorus was just melted in a test-tube under the acid, and a weighed quantity of iodine projected into it. The iodine dissolved in the phosphorus colouring it deep red; but after the addition of a certain quantity of iodine the substance appeared to explode, and the whole mass was converted into the hard black substance before described. The quantity of iodine projected into the phosphorus before the change, was about 1 equivalent of iodine to 1 of phosphorus. The experiment is best made by first carefully adding the iodine to the phosphorus, and then heating over a lamp until the explosion takes place.

The peculiar phenomena which the distillation of the red phosphorus containing the iodide, as prepared from bisulphide of carbon, presented, induced me to make the following experiments. About 4.2 grms. of phosphorus were carefully melted at the end of a long combustion-tube, and 1.6 grms. of iodine, being in the proportion of 1 equivalent of iodine to 100 of phosphorus, gradually, as before, projected into it. The phosphorus was converted by heating, first to 100° C., at which temperature it solidified, and afterwards in a trough of sand heated to about 200° . The change on removal to the sand was most remarkable. The conversion of the phosphorus could distinctly be followed from one end of the tube to the other. There was evidently a great evolution of heat, and the phosphorus broke up into a series of solid rings. The tube, when cold, was removed to a combustion-trough; the space immediately before the phosphorus heated very hot with charcoal; and the phosphorus distilled to the other end of the tube through the heated part. After the experiment, the phosphorus was found condensed on the sides of the tube, and nearly filling it, as a very hard black mass. Great care is required so to conduct the distillation as not to stop up the tube. The distilled substance contained traces of the ordinary phosphorus, but nearly the whole was in the allotropic form. The allotropic phosphorus passes by distillation into the usual modification, and a curious point suggests itself, whether in this experiment in the presence of the iodine, the allotropic phosphorus distils unaltered, or whether it is altered by distillation and reconverted by the iodide of phosphorus which distils with it. I cannot give a satisfactory answer to this question; but the very peculiar way in which,

as I have before mentioned, like arsenic, the phosphorus sublimes, inclines me to the former view.

The allotropic phosphorus, as prepared by iodine, presents certain differences with the phosphorus converted by heat, which led me at first to doubt whether they were the same substance. It was much more readily acted upon by potash, and precipitated certain metallic solutions—for example, sulphate of copper—in a way which the other phosphorus did not. It slightly lost weight also on drying in a current of hydrogen at 100° , which is not the case with the other phosphorus. My opinion now is, that these differences arise from the presence in the phosphorus of a small quantity of iodine and possibly also of oxygen (if it has been boiled with water), which adhere pertinaciously to the substance. We know that in many cases the presence of small quantities of foreign matter alters materially chemical reactions. The experiments, however, which I made, with the view of ascertaining this point, have some value. I oxidized the phosphorus by boiling with aqua-regia, in the presence of a small quantity of nitre, and repeatedly evaporated to dryness, to ensure the conversion of the whole substance into phosphoric acid, which I determined as pyrophosphate of magnesia. In the two following experiments, a preparation of phosphorus, made by distillation of the iodide, was further purified by boiling for three days in a retort with water, and afterwards drying *in vacuo*. The substance on the filter washed with boiling water, gave no trace of iodine. This substance thus determined, gave a quantity of pyrophosphate, corresponding in two experiments to 101.8 and 100.6 of phosphorus in 100 parts of the original substance. Two experiments with another preparation gave 100.06 and 99.390 per cent, assuming, that is, the equivalent of phosphorus as 32, and that of magnesia as 12.2. Three comparative experiments, made with the allotropic phosphorus converted by heat, gave 105.36—105.84 and 105.51 of phosphorus in 100 parts of the original substance on the same assumption, giving a mean of 105.57 per cent. An experiment with the ordinary phosphorus, with which, for obvious reasons, the result may not be quite so accurate, gave 104.57 per cent of phosphorus in 100 parts. The determination with pyrophosphate of magnesia, made with care, gives most concordant results; and I have no doubt but that the apparent anomaly of the experiments arises from the assumption of a wrong atomic weight of phosphorus. The recent experiments of Schrötter* have given 31 for its equivalent

number. The mean of the three experiments with the allotropic phosphorus above given, requires 30.31. The subject requires further investigation.*

I compared also the specific gravity of the two preparations. It was taken in bisulphide of carbon, of which the specific gravity was taken immediately after the experiments. Two experiments with the phosphorus prepared by iodine gave a specific gravity of 2.22 and 2.24, mean 2.23. Three experiments with the phosphorus prepared by heat gave 2.14, 2.13, 2.14 specific gravity, mean 2.14. The density of this substance, determined by Schrötter† at 10°, is 1.964. My determinations, however, are likely to be more accurate, as Schrötter took the density in water, with which the phosphorus cannot be wetted. Assuming this density and the above equivalent number 30.3, the atomic volume of phosphorus = $\frac{378}{2.14}$, becomes 176, being nearly the same as that of arsenic, which is 167.

In the preceding experiments, I have not only shown the result of this action of iodine upon phosphorus, but have analysed the process by which this result is produced. I consider that it may be accounted for by the known laws of chemical action. The first step in the series of changes is the combination of iodine and phosphorus, in which most probably the substance described by Corenwinder, I_2P , is produced. The next is the conversion of this substance into the allotropic iodide; and the third, the decomposition of this iodide, with the formation from it of the allotropic phosphorus and a volatile iodide, which decomposition takes place more or less rapidly, according to the temperature. This volatile iodide reacts in a similar manner upon a further portion of phosphorus, and thus the action is infinitely continued. By modification of the process, it may be arrested at any one of these stages.

The time at which the phosphorus truly undergoes the molecular change, appears to me to be the moment of its second combination with the iodine. I consider it as contained in its altered condition in the substance then produced, and I regard the allotropic phosphorus as the product of the decomposition of this body. There are facts similar to this decomposition in the case of other elements. The sulphur formed by the decomposition of chloride of sulphur by ammonia is in the insoluble form. The decomposi-

* In the determinations elsewhere given in this paper, the atomic weight has been taken as 32.

† Ann. Ch. Phys. [3] XXIV, 417.

tion of the selenide* of potassium and of ammonium by water, produces allotropic selenium. From the description given by Sacc,† the same body appears to be formed by the decomposition by water of the liquid chloride of selenium. I know, however, of no other case in which the action is continued.

The iodide of phosphorus, which plays so important a part in the change, nearly disappears in the final result. In the phosphorus distilled with iodine, only traces of it remain. From this we can readily understand how in other cases chemical results may be brought about by means of intervening steps and by the formation of substances of which no trace whatever is ultimately left. This hypothesis has already been to some extent applied to give a rational view of certain chemical changes which could not otherwise be accounted for, but has never received that development in the philosophy of chemistry to which it appears to me to be entitled.

XXIV.—*On the Valuation of Indigo.*

BY DR. FREDERICK PENNY, F.C.S.,

PROFESSOR OF CHEMISTRY IN THE ANDERSONIAN UNIVERSITY, GLASGOW.

Several methods have been employed for estimating the comparative value of commercial indigo.

The colorimetric processes with chlorine, proposed by Berthollet, and first practically applied by Descroizilles, have been most extensively tried, and have been fully described by Berzelius,‡ Chevreul,§ Schlumberger,|| Schubart,¶ Persoz,** and others. In these processes chlorine-water or bleaching-powder was used as the source of the chlorine.

Bolley†† has proposed chlorate of potash and hydrochloric acid as the source of chlorine, and has reported very favourably of

* Chem. Soc. Qn. J. V, 93.

† Ann. Ch. Phys. [3] XXXII, 385.

‡ Traité de Chimie.

§ Leçons de Chimie appliquée à la Teinture.

|| Bullet. de la Soc. Industr. XV, 277.

¶ Tech. Chimie.

** Traité de l'Impression des Tissus.

†† Ann. Ch. Pharm. 1850.

the results obtained by operating upon specimens of various qualities.

Some chemists consider that the only method of accurately determining the value of this article consists in removing the various impurities by the successive action of diluted acid, caustic alkali, alcohol and water, and then ascertaining the quantity of indigo-blue that remains, the ash being deducted in the usual manner. Others, again, prefer the process of reducing the indigo-blue by deoxidizing agents, and afterwards precipitating and collecting it in the pure state. This method was, about the commencement of the present century, adopted by Pringle,* who employed the well-known materials, sulphate of iron and lime, as the reducing and dissolving agents, and separated the indigo-blue from the clarified solution with hydrochloric acid. The operations involved in this process are exceedingly tedious, and in consequence of the peculiar property which reduced indigo has of forming two distinct combinations with lime, the one soluble, and the other insoluble (a fact not known to Pringle), the results afforded by it are not always satisfactory.

Dana† has recommended another method, based, however, on the same principles. It consists in boiling the indigo in caustic soda, and cautiously adding protochloride of tin until the indigo-blue is completely reduced and dissolved; the clear solution is then precipitated by bichromate of potash, and the precipitate being well washed with dilute hydrochloric acid, is dried and weighed.

Fritzsche‡ has suggested cane-sugar, alcohol and caustic soda for the reduction and solution of the indigo-blue. His process, which appears, however, to be better adapted for the preparation of pure indigo, than for testing its value, has been repeated and favourably spoken of by Marchand; and Berzelius says that it surpasses all other methods that have been employed for obtaining indigo-blue in a state of purity.

Chevreul's method of dyeing cotton until the indigo-solution is exhausted is obviously very objectionable.

Reinseh,§ after trying various modes, prefers that of dissolving a grain and a half of the indigo in concentrated sulphuric acid, and then estimating its comparative value by the quantity of water required to be added to reduce the colour of the solution to a certain shade. This process, which is simple and convenient, is in every respect similar to

* *Annales des Arts et Manufac.* VI, 214—239.

† *J. pr. Chem.* XXVI, 398.

‡ *J. pr. Chem.* XXVIII, 16.

§ *Jahrb. prak. Pharm.*

that long since applied by Ure,* though Persoz† ascribes it to Houton-Labillardière.

The advantages and disadvantages of these processes have been so fully discussed by Bolley in his paper, before referred to, that it is unnecessary, I conceive, to make any further comment on their respective merits.

The method I have now to propose, is based upon the circumstance that indigo-blue in presence of hydrochloric acid, is decolorised by bichromate of potash. This salt has long been used for discharging indigo-blue and other colours in the printing of textile fabrics, as well as for bleaching oils, fats, and several other substances. In employing it for estimating the comparative value of commercial indigo, the necessary manipulations are extremely simple.

Ten grains of the sample, in very fine powder, are carefully triturated with two drachms by measure of fuming sulphuric acid, and the mixture being excluded from the air is allowed to digest with occasional stirring for twelve or fourteen hours. A small flat-bottomed flask with a tightly fitting cork, is a very convenient vessel for this operation. Some pieces of broken glass should however be thrown in to facilitate the contact of the indigo and acid during the agitation, and thus to prevent the aggregation of the former into small clots, which the acid by itself cannot penetrate. If a small capsule or test-glass be used, it should be covered, during the digestion, with an air-tight gas-jar. It will also be found advantageous to place the mixture in a warm situation, say between 70° and 80° F., that the action of the acid may be fully developed; a higher temperature than this must be avoided, as sulphurous acid is liable to be produced, and the trial in consequence completely vitiated. Great care must be taken to insure the perfect solution of the indigo-blue in the acid. This result being accomplished, the solution is poured slowly, with constant stirring, into a pint of water contained in a basin, and $\frac{2}{4}$ of a volume ounce of strong hydrochloric acid immediately added, the flask or capsule being rinsed clean with water.

An alkalimeter of 100 equal measures, is now made up in the usual way with $7\frac{1}{2}$ grains of dry and pure bichromate of potash, and the solution added in small successive portions to the diluted sulphate of indigo in the basin, until a drop of the mixture, on being let fall on a white slab or slip of bibulous paper, presents a distinct light brown or ochre shade, unmixed with any blue or green. The process is then

* J. Roy. Inst. 1830.

† Traité des Tissus, I, 131.

finished; the number of measures of bichromate used is read off, and this number shows the comparative value of the indigo subjected to the trial.

In applying the test-drop to the bibulous paper, the best results are obtained by bringing the end of a glass rod into contact with the indigo-solution, and then gently pressing it against the surface of the paper. The stain thus produced will be circular and conveniently localised to a small space. By using bibulous paper it will also be found much easier to recognise the last traces of the blue colour than when a slab is employed, and the results, when dry, may be preserved unchanged for reference or comparison.

It is advisable to keep the indigo-solution gently heated while the chrome-liquor is being added; and it is essentially necessary that the mixture should be well stirred after each addition. Several measures of the chrome-solution may at first be poured in without risk of error, but towards the conclusion, the liquor must be added very slowly and with great care, as one or two drops will then be found to produce a very decided effect. The characteristic changes of colour which the mixture undergoes during the addition of the chrome-solution, will distinctly indicate the approach of the process towards conclusion. The blue colour of the solution gradually diminishes in intensity, becoming perceptibly lighter and lighter, and after a time it acquires a greenish shade, which soon changes to greenish-brown, and almost immediately to light ochre-brown.

I have tried this process very carefully upon pure indigo, prepared according to Fritzsche's method. The mean of three experiments, which gave results almost identically the same, showed that 10 grains of pure indigo require very nearly $7\frac{1}{2}$ grains of bichromate of potash; and I have accordingly taken this quantity of the salt for solution in the alkalimeter.

The following table contains the results of trials upon three series of specimens of commercial indigo, and includes likewise the price of each sample, and the amount of ash left after careful incineration, as well as the moisture expelled at 212° . The first series of samples was obtained from an indigo broker, in London; the second from Messrs. C. Tennant & Co., Glasgow; and the third from Messrs. R. and I. Henderson, Glasgow.

FIRST SERIES.

SPECIMENS.	Price, 1851.		Alkalimeter measures consumed.	Ash per cent.	Water per cent.
	<i>s.</i>	<i>d.</i>			
East Indian . . .	6	4	68	4.5	5.0
” ” . . .	6	0	66	5.8	6.0
” ” . . .	5	9	64	8.1	8.0
” ” . . .	5	6	54	11.0	7.0
” ” . . .	4	9	51½	7.2	7.5
” ” . . .	4	8	54	3.6	7.0
” ” . . .	4	4	45	14.0	8.4
Spanish . . .	4	3	55	12.3	6.0
” . . .	3	10	50	13.0	7.0
” . . .	3	6	44½	19.0	5.5
” . . .	2	10	28	33.4	4.5

SECOND SERIES.

SPECIMENS.	Price, 1851.		Alkalimeter measures consumed.	Ash per cent.	Water per cent.
	<i>s.</i>	<i>d.</i>			
Bengal . . .	5	0	64	5.9	4.0
” . . .	4	9	47	24.6	5.0
Benares . . .	4	6	45	20.7	8.4
Guatemala . . .	4	3	50	16.0	6.5
Madras . . .	3	8	41	10.6	6.7
Oude . . .	3	8	46	6.3	8.5
Caraccas . . .	3	6	52½	16.2	6.4
Madras . . .	2	9	35	33.3	6.0

THIRD SERIES.

SPECIMENS.	Price, 1852.		Alkalimeter measures consumed.	Ash per cent.	Water per cent.
	<i>s.</i>	<i>d.</i>			
Java . . .	5	6	63½	5.4	4.8
Bengal . . .	4	10	59½	7.5	5.0
” . . .	4	0	56	11.0	5.3
” . . .	3	4	45½	14.0	7.2
” . . .	1	6	24	44.4	4.4
Manilla . . .	3	4	35½	28.0	5.0
” . . .	2	0	26½	50.0	5.4

The results in these tables clearly show the uncertainty, and in several instances the positive inaccuracy, of the common methods at present employed by commercial men for estimating the true value of this article. The indications of quality afforded by colour, fracture, texture, coppery hue when rubbed, cleanliness, weight, and other characters, should always in my opinion be confirmed by the application of a simple chemical process, such as I have here described. The objection on the score of the time consumed, so strongly urged against many of the other methods, is certainly not chargeable against this; for, by steeping the indigo in the acid overnight, twenty or thirty samples at least could be easily tested in a day, and at a trifling expense.

I may mention that there was recently sent me for examination a specimen of indigo, offered in Glasgow as refined indigo, at 10s. per lb. It gave 9 per cent of ash, and $2\frac{1}{2}$ per cent of moisture; and 10 grains, when dissolved in sulphuric acid, consumed 82 measures of the bichromate of potash solution. It is in very fine powder, with a deep coppery-blue colour. Assuming its quality and purity to be uniform, it would unquestionably be more economical, even at the high price of 10s. per lb., than much of the indigo at present sold. Its tinctorial powers could be relied on; and from the circumstance of its being finely pulverized, it obviously admits of being rigorously tested by the bichromate process.

The method here proposed is open, I am well aware, to some of the many objections that have been advanced against the well-known chlorine process. It is quite obvious, for instance, that unless particular care is taken in dissolving the indigo in the sulphuric acid, not only is a part of it liable to escape solution and proper estimation, but in the case of inferior indigo, sulphurous acid may be produced, which would of course involve a larger consumption of the bichromate of potash than the indigo-blue itself would require. It may also be objected that bichromate of potash, in the presence of hydrochloric acid will act upon the other constituents of ordinary indigo; but so far as I have been able to judge from a very extensive course of experiments upon a great variety of specimens, the amount of these influences is extremely slight, and altogether inappreciable when the process is executed with proper care. The same opinion has been expressed by Berzelius and Schlumberger regarding the chlorine process; and it is further supported by the fact, that indigos containing a large proportion of brown and other colouring matters, consume a very small quantity only of the bichromate. While, therefore, this process has no pretensions to supply scientific men

with the means of determining the actual amount of pure indigo-blue in samples of commercial indigo, it is in my opinion admirably adapted for ascertaining their relative values, being in many respects superior to those which have hitherto been proposed.

The bichromate of potash possesses in an eminent degree all the qualities requisite for a trustworthy agent of valuation, being easy of purification, unchangeable by keeping, and of uniform composition.

XXV.—*On the Constitution of Stearine.*

BY PATRICK DUFFY.

STUDENT IN THE BIRKBECK LABORATORY, UNIVERSITY COLLEGE, LONDON.

A specimen of stearine from mutton fat, having its second melting-point at $62^{\circ}\cdot 5$, and, therefore, nearly identical with the substances analyzed by Lecanu* and Heintz† respectively, burned with chromate of lead, gave the following results:

I.	0.2989	gm.	gave :
	0.8483	„	carbonic acid, and
	0.3277	„	water.
II.	0.2706	„	gave :
	0.7677	„	carbonic acid, and
	0.3026	„	water.
III.	0.2670	„	gave :
	0.7544	„	carbonic acid, and
	0.2941	„	water.
IV.	0.2820	„	gave :
	0.7943	„	carbonic acid, and
	0.3148	„	water.
V.	0.3492	„	gave :
	0.9858	„	carbonic acid, and
	0.3858	„	water.

These numbers correspond to the following quantities per cent :

* J. Pharm. [3] XX, 325; Ann. Ch. Phys. [2] LV, 192.

† Pogg. Ann. LXXXIV, 229. It is, perhaps, proper to state that it differed from theirs in being the second crop of crystals in the twenty-fifth ethereal solution of mutton fat, instead of the first crop in the sixth or seventh solution.

	I.	II.	III.	IV.	V.
C.	77·40	77·37	77·05	76·81	76·99
H.	12·18	12·42	12·23	12·40	12·27
O.	10·42	10·21	10·72	10·79	10·74

The following are the numbers obtained by Lecanu and Heintz, also the melting-point given by them. Liebig and Pelouze do not mention the melting-point of the stearine analyzed by them, and Artzbächer's melted at 60°·6, so that a comparison of their results with the others is not admissible.

	Lecanu.	Heintz.	Mean of mine.
Second melting-point	62°	62°	62°·5
C.	76·90	76·74	77·12
H.	12·44	12·42	12·30
O.	10·66	10·84	10·58

1·8297 grm. of this substance was saponified in a small flask by a solution of potash in alcohol; the alcohol nearly all distilled off in the water-bath; and water added, which formed a clear solution of the soap. This solution was heated in the water-bath till all smell of alcohol disappeared; the soap was decomposed by dilute sulphuric acid in slight excess, the liberated fatty acid allowed to collect and solidify; and the water containing the sulphate, or sulphoglycerate of potash, removed by a delicate pipette: it was slightly opalescent from precipitation of a small quantity of silica, which the potash had removed from the flask. The fatty acid was afterwards washed, till the washings ceased to leave any residue on evaporation, and till the acid ceased to lose weight by washing, and subsequent drying at 100°. It then weighed 1·7521 grm.

In a second similar operation, 1·4056 grm. of stearine afforded 1·3426 grm. of acid.

In a third operation, 1·0399 grm. of stearine afforded 0·9931 grm. of acid. A determination of the glycerine produced in this operation was also made; for that purpose, the solution of sulphate of potash, mixed with glycerine, was evaporated by a steam-heat nearly to dryness; dry carbonate of potash added; the glycerine extracted by absolute alcohol; and the alcoholic solution was filtered and evaporated over sulphuric acid in the air-pump vacuum till it ceased to lose weight. From the weight so obtained, was deducted that of the small quantity of sulphate and carbonate of potash left on burning off the glycerine. The glycerine weighed 0·093 grm.

The acid of each operation was fusible at 64°·7 into a perfectly limpid liquid.

These quantities compared to 100 parts of the stearine are as follows :

	I.	II.	III.	Mean.
Acid . . .	95.76	95.51	95.50	95.59
Glycerine . .	—	—	8.94	8.94

The acid, burned with chromate of lead, gave the following results :

- I. 0.2969 grm. of first operation gave :
 - 0.8258 „ carbonic acid, and
 - 0.3320 „ water.
- II. 0.3164 „ of second operation gave :
 - 0.8787 „ carbonic acid, and
 - 0.3572 „ water.

These numbers correspond to the following percentages :

	I.	II.	Mean.
C.	75.85	75.74	75.79
H.	12.42	12.54	12.48
O.	11.73	11.72	11.73

The equivalent weight* of the acid was determined from its silver and soda salts. A portion of the acid was added to a solution of pure carbonate of soda, which was boiled till saponification was complete, and then evaporated to dryness; the resulting soap was removed from the excess of carbonate of soda† by treatment with boiling absolute alcohol and filtration; the alcoholic solution of soap was evaporated to dryness, and the remaining soda-salt dissolved in water; and from this solution the silver-salt was prepared by precipitating with nitrate of silver, washing the precipitate, and drying at 100°, keeping it protected as much as possible from daylight.

0.5893 grm. silver salt of acid of first preparation left on ignition 0.1638 grm. silver.

* The term "equivalent weight," is here used in preference to that of "atomic weight," as the latter is not strictly applicable in respect to substances consisting of a mixture. In some instances in this paper, where this reason for its use does not apply, it has been retained for the sake of uniformity. Another reason was, that in speaking of equivalents it was not required to take into consideration the fact of the acid being bibasic, which would only have complicated the remarks that follow.

† Carbonate of soda dissolves in small, but, for questions of atomic weight, important quantities, in absolute alcohol; but I have some reason to think that it is quite insoluble in an alcoholic solution of soap, which is just the opposite of what occurs with aqueous solutions, for here the carbonate of soda renders the soap insoluble. I had not an opportunity of fully investigating this point.

- I. 0·4102 grm. soda salt of acid of second preparation afforded :
 0·0986 „ sulphate of soda.
 II. 0·3415 „ of same salt afforded :
 0·0811 „ sulphate of soda.

A mixture of acids, of which 4 equivalents consist of 3 equivalents of stearic acid ($C_{34}H_{34}O_4$), and 1 of oleic acid ($C_{36}H_{34}O_4$), would require the following percentages :

	Calculated	Found.
C.	75·82	75·79
H.	12·45	12·48
O.	11·73	11·73

and in its salts :

		Calculated.	Found.	
			I.	II.
Silver	.	28·42	27·79	—
Sodium	.	7·89	7·85	7·76

It is not intended to be implied that the acid analysed actually consisted of stearic and oleic acids in the proportions indicated ; on the contrary, it must have contained, if any, only a trace of oleic acid ; the assumed mixture is taken only for the convenience of calculation, inasmuch as its composition and equivalent weight closely represent those found.

100 parts of the fat contained 77·12 of carbon ; the 95·62 parts of acid derived from them contained 72·44 parts of this carbon ; the difference, viz., 4·68, is all that went to form glycerine.

The equivalent weights of the fat and acid are obviously in the proportion of 100 : 95·62, but the equivalent weight of the acid, according to the foregoing determinations, is 273 ; hence, the equivalent weight of the fat must be 285, which agrees with what we might deduce directly from its own analysis.

It has hitherto been supposed that any fat, such as stearine, which on saponification is resolved into a certain acid and glycerine, consists of this acid combined with a hypothetical base, oxide of lipyl (C_3H_2O) ; and that the process of saponification is merely a case of substitution, 1 equivalent of the alkali or other oxide employed, changing places with 1 equivalent of the oxide of lipyl, and combining with the acid to form soap, while 2 equivalents of oxide of lipyl, together with 4 equivalents of water combine to form hydrated glycerine ($C_6H_8O_6$).

If this represented what took place in the present instance, the loss of carbon sustained by the fat on being converted into acid, should have been to the fat, in the proportion of 3 equivalents of carbon to 1 of fat, or $\frac{1.8}{2.85}=6.31$ per cent of the fat. The actual loss was, however, only 4.65 per cent, a result which coincides closely with those found by Chevreul* in similar analyses of mutton, pork and human fats, each in the crude state. These fats, on being converted into acid, lost respectively 4.181, 4.685, 4.493 per cent of carbon.

Inasmuch as these fats were analysed by Chevreul in the crude state, while that which I operated upon was comparatively pure, it might be thought that, the conditions being thus different, any coincidence in the results can only have been accidental, and may have originated in a different source from that supposed, but Chevreul has left numerical data sufficient for making the calculations here required independently of the contrary hypothesis.

The crude acid which he obtained from these fats, when heated with oxide of lead, lost in each case the same quantity of water, viz., 3.65 per cent; its equivalent weight was therefore 246; consequently, the equivalent weights of the several fats were to 246 in the proportion of 100 to the percentage of acid obtained from them respectively, or as 100:96.5 for the mutton fat, 100:95.9 for the pork fat, and 100:96.18 for the human fat; that is, as 254, 256 and 255 respectively. Now, if 1 equivalent of each of these fats, on being converted into acid, had lost 3 equivalents of carbon, the difference between the quantity of carbon in 100 parts of the fat, and that in the percentage of acid obtained from it, should have been: in the case of the mutton fat, $\frac{1.8}{2.54}=7.08$ per cent, in the case of the pork fat, $\frac{1.8}{2.56}=7.03$ per cent, and in the case of the human fat $\frac{1.8}{2.55}=7.05$ per cent.

If we admit that the proportion of the fat, which in saponification goes to form glycerine, contains not 3, but 2 equivalents of carbon, we come much nearer the actual result. The agreement between the calculated and found quantities is then as follows:

	Calculated.	Found.	Glycerine found represents
Purified mutton fat . .	4.21	4.68	3.498
Crude mutton fat . .	4.72	4.181	3.130
„ pork fat . . .	4.68	4.685	3.451
„ human fat . . .	4.70	4.495	3.780

* Rech. Chim. sur les Corps Gras, Paris, 1823, 333—343.

Further, upon the lipyl theory, the difference between a fat and the hydrated acid producible from it, is that the latter contains 1 equivalent of water (HO), instead of 1 equivalent oxide of lipyl (C_3H_2O) in the former; consequently, the oxygen in an equivalent of either should be the same; but the analyses do not support this view. The oxygen found in 100 parts fat and their equivalent of acid is as follows:

		Crude (Chevreul):		
		Mutton.	Pork.	Human.
Acid . . .	Purified mutton. 11·21	10·132	10·253	10·633
Fat . . .	10·58	9·304	9·756	9·584
Excess in acid	0·63	0·828	0·497	1·049

According to these experiments, the acid did not derive all its oxygen from the fat. Is the excess only apparent, and belonging really to the errors of experiment; or is it due to the circumstance of any oleic acid present in the acid undergoing oxidation during the operations of drying, weighing, &c.; or does it represent a definite quantity of oxygen taken up in the form of water during saponification? The latter is most probable; for, firstly, the concordance of all Chevreul's analyses with mine in showing an excess, would probably not have occurred, if it had been due to accident. Secondly, there must have been extremely little oleine in the fat, and a correspondingly small quantity of oleic acid in the acid which I operated upon; and if it had arisen from the absorption of oxygen by any oleic acid possibly present, this absorption being gradual would have been discovered by a gradual increase of ·007 to ·01 gm. in the weight of the acid in my determinations; but although the acid was kept melted and exposed to the air for hours, no increase of its weight occurred. Thirdly, Chevreul's experiments* show that free oxygen is not taken up in saponification; the only remaining source of this increase is therefore the water used. Other experiments, to be mentioned presently, show that when alcohol is used instead of water, saponification does not occur in the ordinary way.

Upon the supposition that in the formation of 4 equivalents of acid there is taken up 1 equivalent of water, I should have found the increase of oxygen 0·70 per cent; and in the fats analyzed by Chevreul it should have been 0·78 per cent for each.

As to the relation between the hydrogen in the fat and that in the acid, it is scarcely possible to arrive in this manner at any definite

* Rech. Chim. sur les Corps Gras, 323—329.

expression for it; for where a single equivalent of it does not, as in the present instance, amount to more than $\frac{1}{28.5}$ th part of the substance, ordinary analysis can hardly decide between one equivalent more or less. The hydrogen in 100 parts fat, and in their equivalent of acid, appears from the analyses, as follows:

		Crude (Chevreul):		
	Purified mutton.	Mutton.	Pork.	Human.
Fat . . .	12.30	11.700	11.146	11.416
Acid . . .	11.93	11.553	11.234	11.040
	0.37	0.147	-0.088	0.376

With the exception of that of the pork fat, these analyses concur to show that the fat, on being converted into acid, loses hydrogen; the analysis of the pork fat shows an increase of 0.088 per cent in the acid.

Upon the supposition that the fat contains 1 equivalent of hydrogen more than the acid, I should have found a difference of 0.35; but this theoretical difference is reduced to 0.26, if we admit that the increase of oxygen has been taken up as an equivalent of water in the formation of 4 equivalents of acid. The hydrated acid contains 1 equivalent of basic hydrogen, which it did not derive from the fat; hence the conclusion is, that the part of the fat which goes to form the acid contains 2 equivalents of hydrogen less than the fat itself.

What I consider particularly established by the foregoing facts is, that an equivalent of fat, in being converted into one of acid, loses 2 equivalents of carbon; and that a given quantity of acid contains more oxygen and less hydrogen than the portion of fat from which it is derived.

Liebig and Pelouze* represented stearine by the formula $2\text{St}, \text{GlyO}, 2\text{HO}$, regarding it as analogous to sulphoglyceric acid; but Heintz has already remarked that the analyses, from which this formula was deduced, are at variance with those made by Lecanu, Artzbächer and himself, and, I may add, with those which I have made.

I have also made the following analyses of mutton stearine, which, after thirty-two crystallizations from ether, melted at 52° , $64^\circ.2$ and $69^\circ.7$, and furnished an acid melting at $66^\circ.5$. Burnt with chromate of lead:

* Ann. Ch. Pharm. XIX, 264; J. pr. Chem. 173; Ann. Ch. Phys. [2] LXIII, 146.

- I. 0.2760 grm. gave :
 0.7745 „ carbonic acid, and
 0.3050 „ water.
- II. 0.3081 „ gave :
 0.8652 „ carbonic acid, and
 0.3360 „ water.
- III. 0.2689 „ gave :
 0.7218 „ carbonic acid, and
 0.2927 „ water.
- IV. 0.2974 „ gave :
 0.8310 „ carbonic acid, and
 0.3256 „ water.
- V. 0.2887 „ gave :
 0.8075 „ carbonic acid, and
 0.3106 „ water.

These numbers correspond to the following per cent :

	I.*	II.	III.	IV.	V.
C . .	76.53	76.56	76.02	76.20	76.28
H . .	12.27	12.11	12.10	12.16	11.95
O . .	11.20	11.33	11.88	11.64	11.77

The following analyses of beef stearine, having its several melting-points at 51°, 63° and 67°, were made with chromate of lead.

- I. 0.4709 grm. gave :
 1.3264 „ carbonic acid, and
 0.5187 „ water.
- II. 0.2873 „ gave :
 0.8098 „ carbonic acid, and
 0.3143 „ water.

These numbers correspond to the following quantities per cent :

	I.	II.
C	76.87	76.87
H	12.24	12.15
O	10.89	10.98

* Analyses I. and II. were made of the substance after it had been dried at 100°; the others were made of the crystals from ether, after they had been dried over sulphuric acid in the air-pump vacuum till they ceased to lose weight. It is probable that the difference between the carbon in the two series of analyses, arose from the crystals in the latter case having retained a trace of ether, and hence, that the numbers in the first two analyses are most nearly correct.

Beef stearine has accordingly the same composition as mutton stearine. In beef stearine, having its second melting-point at $60^{\circ}6$, Artzbücher* found 2 per cent more carbon. The difference in the purity, as indicated by the melting-point, of the substances which we analysed, cannot, I think, account for this discrepancy in our results. He has fallen into an error in supposing that his results agree with those of Chevreul and Lecanu; for in Chevreul's "*Recherches Chimiques sur les Corps Gras*," I can find no account of any ultimate analysis of either crude or purified beef fat; and Lecanu† appears to have analysed stearine from mutton fat only.

To 1.019 grm. of mutton stearine, having its second melting-point at $62^{\circ}5$, and 3.075 grms. of pure oxide of lead in fine powder, absolute alcohol was added in quantity sufficient to dissolve the stearine readily when heated. The whole was kept boiling in the water-bath, and frequently agitated during four hours, the alcohol being replaced as it evaporated. At the end of this time the oxide of lead retained its yellow colour, and nearly the whole of the stearine was recovered unaltered, except for the admixture of a trace of impalpably fine oxide of lead. No lead-soap appeared to have been formed. The difference between the circumstances of this experiment and those of the ordinary process of forming lead-plaster, was that the water of the latter operation was replaced by alcohol, yet this was sufficient to prevent saponification.

The following experiment was performed before those already detailed, accordingly in the belief that the fats were analogous to ordinary salts, and that saponification consisted, as represented, in an exchange of places between the alkali employed and the oxide of lipyl or other base of the fat; the only question was, as to what this base was. The intention was to procure a body corresponding to ordinary glycerine, but in which the water taken up by the base of the fat, on its liberation and conversion into glycerine, should be substituted by ether.

The experiment consisted in acting in the first instance upon stearine by the compounds procured by the action of the alkali-metals on pure alcohol, which, from their analogy with the hydrates of the alkalies, have been called the ethylates of the alkalies by Dr. Williamson. Two grms. of sodium were dissolved in a quantity of absolute alcohol sufficient to dissolve 23.803 grms. of stearine, which were added. (The propor-

* Ann. Ch. Pharm. LXX, 239; Compt. Rend. des Trav. de Chim. 1849, 343.

† J. Pharm. [3] XX, 325; Ann. Ch. Phys. [2] LV, 192.

tions of sodium and stearine are nearly those of equivalent quantities, the sodium being slightly in excess.) The whole was boiled for some time, and on being allowed to cool, it stiffened into a jelly, showing that a soap had been formed; the alcohol was then distilled off in the water-bath, and the soap dissolved in water. On the surface of the solution an oily stratum formed, which was removed by a pipette, washed with water, and the washings added to the solution of soap. The soap, being decomposed by hydrochloric acid, the fatty acid was collected, washed, dried, and weighed; it amounted to 17·481 grms. The oily substance when dried, weighed 5·571 grms. A quantity of glycerine, which was not weighed, was found in the liquid from which the acid had been removed. The oily substance solidified on cooling into a semi-transparent mass, melting again at 29° . It dissolved readily in alcohol and ether. By crystallisation, from the former, its melting-point was raised to $33^{\circ}\cdot7$. It did not crystallise from ether, was not sensibly affected by aqueous solution of potash, but was readily saponified by an alcoholic solution of potash. On distillation, the temperature rose gradually to 224° C., the substance came over partially decomposed, and a black mass remained in the retort.

The crystals from alcohol, after being dried over sulphuric acid in the air-pump vacuum till they ceased to lose weight, gave the following results when burned with oxide of copper:

I.	0·3200	gram.	gave :
	0·8980	„	carbonic acid, and
	0·3600	„	water.
II.	0·4255	„	gave :
	1·1720	„	carbonic acid, and
	0·4920	„	water.
III.	0·3273	„	gave :
	0·8999	„	carbonic acid, and
	0·3796	„	water.

These numbers correspond to the following percentages :

	I.	II.	III.
C. . .	76·53	75·12	74·99
H. . .	12·50	12·85	12·88
O. . .	10·97	12·03	12·13

Although the analyses are not satisfactory, there can be no doubt, after all these facts, that this is the same substance as the stearic

ether prepared by Redtenbacher.* In short, I prepared this substance in the same manner that he did; viz. by passing a current of hydrochloric acid gas into a solution of stearic acid in alcohol, and found all its physical characters the same as those of the substance prepared by the action of ethylate of soda upon stearine.

Here are the numbers obtained by Redtenbacher in the analysis of stearic ether :

C.	.	.	.	.	76·13
H.	.	.	.	.	12·88
O.	.	.	.	.	10·99

In order to determine whether any more volatile products were formed in this reaction, 0·8187 grm. of stearine was acted upon by a quantity of ethylate of soda containing 0·0772 grm. of sodium. The stearine was placed in a tube inside a small flask, in such manner that no communication occurred between the stearine and the ethylate of soda, till the flask was filled with alcohol vapour, and all the air expelled from it. The orifice of a conducting tube, inserted in the neck of the flask, was then introduced under a mercury barometer standing in a mercury trough; by a slight inclination of the flask, the melted stearine was allowed to flow out of the tube into the ethylate of soda, the heating being continued. By this arrangement, any gaseous products formed in the decomposition would have been collected above the mercury in the barometer, and have produced a depression corresponding to their elastic force; but there were none, unless alcohol vapour; for the depression of the column was only from 30°·15 inches before the operation, to 28°·6 after it, or 1·55 inch, the temperature being 20°; and the same depression exactly was produced by a few drops of alcohol admitted into another similar barometer. Stearic ether was found to have been formed.

When stearic acid is substituted for stearine in this reaction, no ether is produced. To a quantity of ethylate of soda, containing 0·02 grm. of sodium, 0·25 grm. of stearic acid was added; stearate of soda was the only product.

Amylate of soda was formed by adding 0·445 grm. of sodium to pure amylic alcohol, and to this 5·46 grms. of stearine were added; a quantity of oily substance was formed which, being freed from soap by washing, and from amylic alcohol by being heated in an oil-

* Ann. Ch. Pharm. XXXV, 51.

bath for some time at 185° , melted at $25^{\circ}\cdot 5$, and was in every respect similar to stearate of amyl prepared by passing hydrochloric acid gas into a solution of stearic acid in amylic alcohol. At temperatures below its melting-point, it was semi-transparent, soft and glutinous; above its melting-point, it passed into a clear transparent fluid; it was readily soluble in alcohol and ether; it solidified as a jelly on cooling its solution in the former by a freezing-mixture, but did not crystallise from either; it was not acted upon by aqueous solution of potash, but was readily converted by an alcoholic solution of potash, into stearate of potash and amylic alcohol, which then exhaled its well-known odour.

When palmitine was substituted for the stearine, a corresponding result was obtained. To 0.231 gram. of sodium in amylic alcohol 2.598 grms. of palmitine, having its second melting-point 61° , were added. After boiling for some time, a solution of chloride of calcium in amylic alcohol was added, which gave a precipitate; every trace of the amylic alcohol was afterwards driven off; nothing else escaped at the same time; the residue was digested successively with anhydrous ether, absolute alcohol, and water. The ether, when filtered and evaporated, left 0.693 gram. of a substance having a close resemblance to the stearate of amyl, but melting at $13^{\circ}\cdot 5$. Its solution in alcohol, when cooled by a freezing-mixture, became opaque and gelatinous, but not sensibly crystalline. It resembled in every respect palmitate of amyl, which I prepared in the ordinary way with palmitic acid from the same specimen of palmitine.

Burned with oxide of copper and chlorate of potash, 0.246 gram. gave 0.709 gram. carbonic acid and 0.286 gram. water, which correspond to the following numbers per cent :

	Found.	Calculated.
C_{42} . .	78.60	77.30
H_{42} . .	12.91	12.88
O_4 . .	8.48	9.82

The excess of carbon found may have arisen from the palmitine used containing oleine, or a trace of some other fat. I had not enough substance to repeat the analysis.

What was removed by treatment of the lime-soap with alcohol consisted of glycerine, a small quantity of palmitate of amyl, some palmitate of lime, and chlorides.

Water removed inorganic salts only.

When in these decompositions of stearine and palmitine, the proportion of sodium was increased beyond that of 1 equivalent, the quantity of ether obtained diminished, and eventually, with a quantity of sodium which was certainly not less than 2 equivalents, no ether was obtained.

I need hardly state that the effect was similar when ethylate of potash was used. A solution of anhydrous ammonia in absolute alcohol, and which from analogy is ethylate of ammonia, seemed to produce no change on stearine, even when boiled with it for some time.

Considering this reaction of importance with reference to saponification and the constitution of the fats, I have repeated it under every variation of circumstances deemed likely to elicit its explanation, but the preceding are the principal results obtained; and, although several probable reasons might be assigned for it, I know none that can at present be advanced with much confidence.

It is interesting to observe that, while the ethers formed by stearic and palmitic acids, with vinous alcohol, melted respectively at $33^{\circ}\cdot7$ and $21^{\circ}\cdot5$,* the corresponding ethers of these acids with amyllic alcohol melted at $25^{\circ}\cdot5$ and $13^{\circ}\cdot5$; showing an elevation of melting-point with an increase of atomic weight in the acid, and a depression of melting-point with an increase of atomic weight in the alcohol. I was unsuccessful in the attempt to obtain those of methylic alcohol, by passing hydrochloric acid gas into a solution of the acids in purified wood spirit. Should the character alluded to be found to be an instance of a general law as regards the series of fatty acids, we might predicate that cetine and substances of its class are not ethers.

ACTION OF PERCHLORIDE OF PHOSPHORUS ON GLYCERINE.

The intimate connection between the subject principally discussed in this paper and that of the constitution of glycerine, obviously requires that any conclusion admitted of the former must be controlled by results established of the latter. The inferences to be drawn from the results obtained with stearine are not easily reconciled with what is at present admitted of the constitution of glycerine. For this reason, it was intended to investigate the action of perchloride of phosphorus on glycerine.

When glycerine is added to perchloride of phosphorus, a strong

* Frémy found palmitic ether, prepared by means of sulphuric acid, to melt about 21° (Ann. Ch. Pharm. XXXVI, 16).

heat is developed, the mixture becomes glutinous, and in the cold hard. On treatment with water, or better, with carbonate of soda, a substance considerably denser than water, and very like precipitated silica, is obtained. In performing the reaction, it is advisable to have the glycerine as concentrated as possible, to add it in small quantities to the perchloride, stirring the mixture after each addition, and to cease adding glycerine as soon as all the perchloride is decomposed. When the glycerine contains much water, or is added at once in large quantity, the perchloride is resolved chiefly into phosphoric and hydrochloric acids, which have the power of dissolving, and at the same time decomposing the new product afterwards formed. The operator must protect himself, particularly his eyes, from the action of the hydrochloric acid fumes necessarily produced in large quantity.

A portion of this new substance was washed till free from every trace of hydrochloric and phosphoric acids, then fused with pure soda; in the nitric acid solution of the fused mass, nitrate of silver gave a copious precipitate of chloride of silver. Nitric acid has very little action on it in the cold, but when warmed dissolves it readily. This solution, rendered alkaline by ammonia, gave no precipitate with sulphate of magnesia. It therefore contains chlorine, but no phosphorus. It dissolves readily in cold solution of potash, very slowly in boiling solution of ammonia, very slowly also in boiling solution of acetic acid; it is not reprecipitated from any of these reagents by neutralisation; it seems quite insoluble in alcohol and ether. Cold water does not act upon it; but when kept in boiling water, it is very slowly dissolved, being converted into a substance which, on evaporation of its solution, remained as a hard, perfectly transparent body, highly hygrometric, absorbing in a damp atmosphere in four days its own weight of water, and being converted thereby into a glutinous mass. The aqueous solution of this latter substance was found acid to test-paper, but gave no reaction for hydrochloric or phosphoric acid, and did not appear to decompose bicarbonate of soda. The hydrochloric acid solution of the original substance being neutralised, was examined for glycerine; it furnished none. Hydrochloric acid converts it probably into the same substance, as does water.

I was prevented from analysing these substances by the circumstance of my period of study terminating.

XXVI.—*On the compounds of several essential Oils with the Alkaline Bisulphites.*

BY CESARE BERTAGNINI.

(Abstract of a communication made to Dr. Hofmann.)

An inquiry into the deportment of a great number of essential oils with the alkaline bisulphites has led to the following results:

The volatile oils, having the characters of aldehydes, which are more generally known under the term of hydrides, such as hydride of benzoyl, salicyl, cuminy, &c., and also the class of compounds, of which the aldehyde *par excellence* is known as the prototype, possess the property of readily forming crystalline compounds with the bisulphites of the alkalies. These compounds are composed of 1 equivalent of the aldehyde, 1 equivalent of the alkaline bisulphite and a variable number of water-equivalents.

Experiments made with a very considerable number of essential oils not belonging to the family of aldehydes, have proved that they are not capable of forming similar compounds.

The compounds in question are readily produced by agitating the oils in the cold with solutions of the bisulphites, or by placing the oils in contact with the alkalies and passing a current of sulphurous acid through the liquids. The white, brilliant, crystalline substances generated in this manner, are entirely insoluble in solutions of the bisulphites and in cold alcohol; they dissolve with facility in water, and are readily decomposed by the action of acids and bases, and likewise by an elevation of temperature, the original aldehydes being reproduced. The formation of these substances may be employed with great advantage in purifying aldehydes, when occurring together with other compounds, or in recognizing their presence in mixed liquids.

The following is a list of the combinations as yet analysed, together with their formulæ.

Compounds with :

Hydride of benzoyl . .	NaO, 2 SO ₂ , C ₁₄ H ₆ O ₂ + 2 Aq
Hydride of nitrobenzoyl {	NH ₄ O, 2 SO ₂ , C ₁₄ { $\frac{H_5}{NO_4}$ } O ₂ + 2 Aq
	NaO, 2 SO ₂ , C ₁₄ { $\frac{H_5}{NO_4}$ } O ₂ + 2 Aq
Hydride of salicyl . .	KO, 2 SO ₂ , C ₁₄ H ₆ O ₄ + Aq
Hydride of anisyl . .	NaO, 2 SO ₂ , C ₁₆ H ₈ O ₄ + Aq
Hydride of cuminyl . .	NaO, 2 SO ₂ , C ₂₀ H ₁₂ O ₂ + 3 Aq
Cenanthaldehyde . .	NaO, 2 SO ₂ , C ₁₄ H ₁₄ O ₂ + 3 Aq
Capraldehyde . .	NH ₄ O, 2 SO ₂ , C ₂₀ H ₂₀ O ₂ + 3 Aq.

PROCEEDINGS
AT THE
MEETINGS OF THE CHEMICAL SOCIETY.

November, 1, 1852.

PROFESSOR DAUBENY, President, in the Chair.

John William Perkins, Esq., and Joseph Török, Esq., of Paris, were duly elected Fellows of the Society.

Robert Murray, Esq., was duly elected an Associate of the Society.

The following donations were announced :

“Smithsonian Contributions to Knowledge, Vols. III. and IV.”

“Report of Commissioners of Patents for 1850 : Part 1. Arts and Manufactures ; Part 2. Agriculture.”

“Report to the Navy Department of the United States on American Coals.”

“Report of the Secretary of War on the Geology and Topography of California.”

“Letter from the Secretary of the Treasury on Hydrometrical Tables, &c.”

“Fifth Annual Report of the Board of Regents of the Smithsonian Institution for 1850.”

“On recent improvements in the Chemical Arts, by Booth and Morfit.”

“Directions for collecting, preserving, and transporting Specimens of Natural History.”

"The American Patent Laws."

"American Zoological, Botanical, and Geological Bibliography for 1851."

"Abstract of the Seventh American Census :"

From the Smithsonian Institution.

"Report of the Jury of the Great Exhibition on Miscellaneous Manufactures :'' from the Reporters.

"Transactions of the Royal Society of Edinburgh, Vol. XX., Part 3., for 1851-52."

"Proceedings of the Royal Society of Edinburgh :'' from the Royal Society of Edinburgh.

"The Quarterly Journal of the Geological Society for August, 1852 :'' from the Geological Society.

"The American Journal of Science and Arts :'' from the Editors.

"Phillips's Elementary Introduction to Mineralogy, by Brooke and Miller :'' from the Editors.

The following Resolution of the Council having been read at three meetings of the Society, was submitted to a ballot, and affirmed unanimously :

"That it be recommended to the Society that the following names be removed from the list of Fellows : Dr. R. H. Brett, Christopher Binks, W. Sands Cox, Isaiah Deck, Stanislaus Desussex, Thomas Griffiths, Thomas Hawkesley, Andrew P. Halliday, Charles J. Hodgson, George W. Mowbray, George Southby, Dr. Wilton Turner, John Turner."

The following papers were read :

1. "On the Valuation of Indigo :'' by Dr. Frederick Penny.
2. "Note on the presence of Alumina in Urine :'' by Lionel S. Beale, M.B.
3. "Note on the reaction of Glycocoll with Potash :'' by Professor Horsford: communicated by Dr. Hofmann.

Mr. G. H. Makins exhibited and explained his improved Assay Balance.

November 15, 1852.

ROBERT PORRETT, Esq., Treasurer, in the Chair.

George Hamilton, Esq., of Liverpool, and Stephen Darby, Esq., of Leadenhall Street, were duly elected Fellows of the Society.

A specimen of leaden bullets, in a highly oxidized state, taken from a cast-iron shell, in which they had been enclosed for fifty years, was presented to the Society by Mr. F. A. Abel.

The following papers were read :

1. "On the Constitution of Stearine:" by Patrick Duffy.
 2. "On the Compounds of several essential Oils with the Alkaline Bisulphites:" by C. Bertagnini, communicated by Dr. Hofmann.
-

December 6, 1852.

ROBERT WARINGTON, Esq., Vice-President, in the Chair.

Dr. John Smith, of Sydney, was duly elected a Fellow of the Society.

The following donations were announced :

- "On the Mechanical Equivalent of Heat, by J. P. Joule, F.C.S."
- "On the Air Engine, by the same."
- "Heat disengaged in Chemical Combinations, by the same."
- "On the Limit to the Magnetizability of Iron, by the same."
- "On a powerful Electro-magnet, by the same."
- "On the economical production of Mechanical Effects from Chemical Forces, by the same:" from the Author.
- "Report of the Jury of the Great Exhibition on Philosophical Instruments, and processes depending upon their use:" from the Reporter.
- "Second Report of the Commissioners of the Exhibition of 1851:" 2 copies, from Dr. Lyon Playfair.

“Lecture on Industrial Instruction on the Continent, by Dr. Lyon Playfair:” from the Author.

“Subjects for Premiums offered by the Society of Arts:” from the Society of Arts.

The following papers were read:

1. “On some new Compounds of Tellurethyl:” by Professor Wöhler, communicated by Dr. Hofmann.

2. “Analytical Notes: I. On the Action of Caustic Potassa on the Phosphates; II. On the behaviour of some Oxides with Caustic Potassa in the presence of Sesquioxide of Chromium:” by A. B. Northcote and A. H. Church.

December 20, 1852.

Dr. Daubeny, President in the Chair.

Thomas William Keates, Esq., was duly elected a Fellow of the Society.

A paper was read:

“On the law of Electrolysis:” by Professor H. Buff.

Mr. Brodie made a verbal communication on the “Construction of Chemical Formulæ.”

TITLES OF CHEMICAL PAPERS

IN

BRITISH AND FOREIGN JOURNALS,

PUBLISHED IN THE YEAR 1852.

A.

Acetone.—On the comportment of acetone with quick-lime : by *C. Völckel*. Ann. Ch. Pharm. lxxxii, 63.

Acid.—Note on a new acid extracted from the mother-liquor of fulminate of mercury : by *S. Cloez*. Compt. rend. xxxiv, 364.

— On the acid of unripe grapes : by *H. Schwartz*. Ann. Ch. Pharm. lxxxiv, 82.

— On a peculiar acid separated in the parenchyma of the lungs : by *F. Verdeil*. Ann. Ch. Pharm. lxxxv, 334.

Acetic.—On the preparation of pure acetic acid from brandy-vinegar : by *C. Völckel*. Ann. Ch. Pharm. lxxxii, 60 ; Chem. Soc. Qu. J. v, 278.

.. .. On the manufacture of vinegar : by *Profs. Graham, Hofmann* and *Playfair*. Pharm. J. Trans. xii, 293.

.. .. On the preparation of pure acetic acid from wood-vinegar : by *C. Völckel*. Ann. Ch. Pharm. lxxxii, 49 ; Chem. Soc. Qu. J. v, 274.

.. .. Improvement in the quick process for manufacturing vinegar : by *A. Wimmer*. Pharm. J. Trans. xi, 578.

.. .. On the action of a red heat upon alcohol and acetic acid : by *M. Berthelot*. Ann. Ch. Pharm. lxxxv, 108.

Antimonic.—On the salts of antimonic acid : by *L. Heffter*. Berl. Monatsbericht, 1852, 344 ; Phil. Mag. [4] iv, 399 ; Pogg. Ann. lxxxvi, 418.

Arsenious.—On the combination of arsenious acid with albumen : by *Mr. Herapath*. J. Pharm. [3] xxi, 35.

Aspartic.—On aspartic and malic acid : by *L. Pasteur*. Ann. Ch. Pharm. lxxxii, 324 ; Ann. Ch. Phys. [3] xxxiv, 30 ; abstr. Chem. Soc. Qu. J. v, 62.

.. .. Report on Pasteur's experiments on aspartic and malic acid : by *M. Biot*. Phil. Mag. [4] iv, 275.

.. .. On aspartic acid : by *J. Dessaignes*. Ann. Ch. Pharm. lxxxiii, 83.

Benzoic.—On the conversion of salicylous acid into monochlorinated benzoic acid : by *L. Chiozza*. Ann. Ch. Pharm. lxxxiii, 317 ; Compt. rend. xxxiv, 850 ; Ann. Ch. Phys. [3] xxxvi, 102.

.. .. On the preparation of benzoic acid by means of superheated steam : by *E. A. Scharling*. Pharm. J. Trans. xi, 469.

- Acid, Benzoaric.—On benzoaric acid, as a supplement to the memoir on urous acid: by *A. Göbel*. Ann. Ch. Pharm. lxxxiii, 280.
- Boracic.—On the compounds of boracic acid and water with lime: by *H. Rose*. Pogg. Ann. lxxxvi, 561; lxxxvii, 1.
- On the action of water on boracic acid and its salts: by *H. Rose*. Pogg. Ann. lxxxvi, 465.
- Camphomethylic.—On camphomethylic acid: by *A. Loir*. J. Pharm. [3] xxii, 288; Compt. rend. xxxv, 328; Chem. Gaz. 1852, 469.
- Capric.—On the occurrence of capric and caprylic acids in some fusel-oils: by *T. Rowney*. Chem. Soc. Qu. J. v, 22.
- Carbonic.—Apparatus for the determination of carbonic acid; by *Max Schaffner*. Ann. Ch. Pharm. lxxxii, 335; Phil. Mag. [4] iv, 317.
- General remarks on the action of water on carbonic acid and the carbonates: by *H. Rose*. Pogg. Ann. lxxxvi, 99, 279; Ber. d. Akad. d. Wissensch. zu Berlin, 1852, 209; Chem. Gaz. 1852, 318.
- On the compounds of the oxides of cadmium and silver with carbonic acid: by *H. Rose*. Pogg. Ann. lxxxv, 302; Chem. Gaz. 1852, 181.
- Compounds of carbonic acid and water with sesquioxide of cobalt: by *H. Rose*. Pogg. Ann. lxxxiv, 547.
- On the combinations of carbonic acid and water with the oxides of cobalt and nickel: by *H. Rose*. Chem. Gaz. 1852, 139.
- On the compounds of carbonic acid with oxide of copper: by *H. Rose*. Chem. Gaz. 1852, 28.
- On the compounds of carbonic acid and water with oxide of zinc: by *H. Rose*. Pogg. Ann. lxxxv, 107.
- On the quantity of carbonic acid in the higher regions of the atmosphere: by *A. Schlagintweit*. Pogg. Ann. lxxxvii, 293.
- Chromic.—On the double salt of chromate of potash and cyanide of mercury: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 145.
- Citraconic.—On certain products of the action of nitric acid on citraconic acid: by *S. Baup*. Ann. Ch. Pharm. lxxxi, 96.
- Citric.—On the constitution of citric acid: by *L. Pebal*. Ann. Ch. Pharm. lxxxii, 78; Chem. Gaz. 1852, 318; *abstr.* Ann. Ch. Phys. [3] xxxv, 469; Chem. Soc. Qu. J. v, 284.
- On the decomposition of citrate of lime in contact with putrefying curd: by *H. How*. Chem. Soc. Qu. J. v, 1.
- On the occurrence of citric acid in *Richardsonia scabra*: by *Rochleder* and *Willigk*. Chem. Gaz. 1852, 43.
- Crenic.—On the existence of organic matter in stalactites and stalagmites, forming crystallized and amorphous crenate of lime: by *D. A Wells*. Sill. Am. J. [2] xiii, 11; Chem. Gaz. 1852, 72.
- Gallic.—On gallic acid fermentation: by *M. Robiquet*. Chem. Gaz. 1852, 297.
- Hippuric.—Examination of certain products derived from hippuric acid: by *N. Socoloff* and *A. Strecker*. Ann. Ch. Pharm. lxxx, 17; Chem. Soc. Qu. J. v, 71.
- On a new method of obtaining hippuric acid in considerable quantity without evaporation of the urine, and on some of its products of decomposition: by *E. Riley*. Chem. Soc. Qu. J. v, 97.

- Acid, Hydrobromic.—On gas-batteries, and on the preparation of hydrobromic and hydriodic acids by the galvanic method: by *G. Osann*. *Phil. Mag.* [4] iii, 317.
- Malic.—Malic acid contained in *Hippophaë rhamnoides*: by *Prof. Erdmann*. *J. pr. Chem.* lv, 191; *Chem. Gaz.* 1852, 253.
- On aspartic and malic acid: by *L. Pasteur*. *Ann. Ch. Phys.* [3] xxxiv, 30; *Ann. Ch. Pharm.* lxxxii, 324.
- Report on Pasteur's observations on aspartic and malic acids: by *M. Biot*. *Phil. Mag.* [4] iv, 275.
- Meconic.—On meconic acid and some of its derivatives: by *H. How*. *Ed. Phil. Trans.* xx, pt. 3, 401; *Ann. Ch. Pharm.* lxxxiii, 350; *Chem. Gaz.* 1852, 301; *abstr. Proc. Roy. Soc. Ed.* 1851-2, 99.
- Mellitic.—On some new salts of mellitic acid: by *C. Karmrodt*. *Ann. Ch. Pharm.* lxxxi, 164.
- Metacetic.—On Dr. Keller's supposed formation of metacetic acid from flour and leather: by *R. W. Forster*. *Chem. Soc. Qu. J.* v, 27.
- Molybdic.—Process of obtaining molybdic acid from native molybdate of lead: by *Chr. Elbers*. *Ann. Ch. Pharm.* lxxxiii, 215.
- Nitric.—On the action of nitric acid on various vegetables, with a more particular reference to *Spartium scoparium*: by *John Stenhouse*. *Phil. Trans.* 1851, ii, 413.
- On the formation of nitric acid: by *H. Bence Jones*. *Ann. Ch. Pharm.* lxxxii, 368.
- Nitrocinnamic.—On the action of sulphide of ammonium on nitrocinnamic acid: by *L. Chiozza*. *Ann. Ch. Pharm.* lxxxiii, 117; *Compt. rend.* xxxiv, 598.
- Nitrotartaric.—On two new acids resulting from the action of nitrotartaric acid: by *M. Dessaignes*. *Compt. rend.* xxxiv, 731; *Chem. Gaz.* 1852, 312.
- On nitrotartaric acid, and on a new acid derived therefrom: by *V. Dessaignes*. *Ann. Ch. Pharm.* lxxxii, 362.
- Nitrous.—On nitrous acid: by *M. Fritzsche*. *J. pr. Chem.* liii, 86; *J. Pharm.* [3] xxi, 229.
- On nitrous acid and nitrosulphuric acid: by *M. Guinot*. *Ann. Ch. Phys.* [3] xxxv, 144.
- Œnanthic.—On œnanthic ether and œnanthic acid: by *W. Delf's*. *Pogg. Ann.* lxxxiv, 505; *Chem. Soc. Qu. J.* v, 279.
- Oxalic. On the manufacture of oxalic acid: *Chem. Gaz.* 1852, 112; *Pharm. J. Trans.* xi, 407.
- Improvements in the chemical preparation of the raw materials used in the manufacture of paper, and in obtaining oxalic acid. *Pharm. J. Trans.* xii, 258.
- Oxysulphocarbonic.—On certain decomposition-products of bioxysulphocarbonate of ethyl, and on the spontaneous decomposition of chemical compounds: by *H. Debus*. *Ann. Ch. Pharm.* lxxxii, 253.
- Pelargonic.—On a compound of pelargonic acid with nitric oxide: by *L. Chiozza*. *Compt. rend.* xxxv, 797.
- Periodic.—On periodic acid and the periodates: by *M. Langlois*. *Ann. Ch. Phys.* [3] xxxiv, 257; *Ann. Ch. Pharm.* lxxxiii, 153.

- Acid, Phosphoric.**—New method of separating phosphoric acid from metallic oxides: by *A. Reynoso*. Ann. Ch. Phys. [3] xxxiv, 301.
- On the determination of phosphoric acid by molybdate of ammonia: by *W. J. Craw*. Sill. Am. J. [2] xiii, 393; Chem. Gaz. 1852, 216.
- Phosphoric acid in normal human urine: by *D. Breed*. Sill. Am. J. [2] xiii, 224.
- On the application of molybdic acid to the determination of phosphoric acid: by *M. Sonnenschein*. J. pr. Chem. liii, 339; Chem. Gaz. 1852, 388.
- Phycic.**—On phycic acid, a new acid obtained from the *Protococcus vulgaris*: by *A. Lamy*. Ann. Ch. Phys. [3] xxxv, 129.
- Picric.**—On picric acid considered as a yellow colouring matter: by *M. Girardin*. J. Pharm. [3] xxi, 30; Pharm. J. Trans. xi, 573.
- Pyromeconic.**—On some salts and products of decomposition of pyromeconic acid: by *J. F. Brown*. Phil. Mag. [4] iv, 161; Proc. Roy. Soc. Ed. 1851-2, 117; Ann. Ch. Pharm. lxxxiv, 32.
- Rhodanhydric.**—On the occurrence of rhodanhydric acid in a sample of commercial ammonia: by *M. Mazade*. Compt. rend. xxxv, 803.
- Salicylic.**—New formation of salicylic acid: by *H. Gerland*. Chem. Soc. Qu. J. v, 133.
- On the transformation of salicylic acid into monochlorinated benzoic acid: by *L. Chiozza*. Ann. Ch. Phys. [3] xxxvi, 102; Ann. Ch. Pharm. lxxxiii, 317; Compt. rend. xxxiv, 850; Chem. Gaz. 1852, 319.
- Silicic.**—On the solubility and hydrated condition of silicic acid: by *J. Fuchs*. Ann. Ch. Pharm. lxxxii, 119.
- Sulphuric.**—Products of decomposition obtained by treating feathers, hedgehog's bristles, hairs, globulin, hæmatin, and the wing-cases of cockchafer with dilute sulphuric acid: by *A. C. Loyer* and *Küller*. Ann. Ch. Pharm. lxxxiii, 332.
- Observations on the formation of sulphuric acid from sulphurous acid and oxygen gas. Ann. Ch. Pharm. lxxxvi, 255.
- On a new compound of the highest chloride of sulphur with sulphuric acid: by *H. Rose*. Pogg. Ann. lxxxv, 510.
- Researches on the compounds of sulphuric acid with organic substances: by *Gerhardt* and *Chancel*. Compt. rend. xxxv, 696.
- New mode of estimating sulphuric acid by means of graduated solutions: by *H. Schwartz*. Ann. Ch. Pharm. lxxxiv, 84.
- Stearic.**—On the detection and determination of stearic acid in bees'-wax: by *M. Overbeck*. J. Pharm. [3] xxi, 39.
- Tannic.**—On the tannic acids, and a new class of nitrogenous derivatives of the tannic acid series: by *A.* and *W. Kuop*. Chem. Pharm. Centr. xxiii, 417; Chem. Gaz. 1852, 338.
- On the constitution of tannic acid: by *A. Strecker*. Ann. Ch. Pharm. lxxxvi, 247; Chem. Soc. Qu. J. v, 102; J. Pharm. [3] xxii, 292.
- Tartaric.**—On the nature and preparation of soluble cream of tartar: by *E. Robiquet*. J. Pharm. [3] xxi, 183.
- On the mode of testing soluble cream of tartar: by *M. Lahens*. J. Pharm. 3 xxi, 110.

- Acid, Tartaric.—On the modifications of tartaric acid produced by heat : by *A. Laurent*. *Compt. rend.* xxxv, 742.
- Ulmic.—On the absorption of soluble ulmates by plants : by *J. Malaguti*. *Ann. Ch. Phys.* [3] xxxiv, 140.
- Uroxanic.—Correction with regard to uroxanic acid : by *Prof. Stüdele*. *Ann. Ch. Pharm.* lxxx, 119.
- Valerianic.—On anhydrous valerianic acid : by *L. Chiozza*. *Compt. rend.* xxxv, 568.
- Acids.—On the action of acids, heat, and the chlorine-compounds of the alkali and earth-metals on oil of turpentine, hydrate of turpentine, sugar and alcohol : by *M. Berthelot*. *Ann. Ch. Pharm.* lxxxiii, 104.
- Estimation of the quantities of free acids in the juices of fruit : by *M. Græger*. *Chem. Gaz.* 1852, 226.
- On the direct formation of hydracids by means of porous bodies : by *B. Corenwinder*. *Ann. Ch. Phys.* [3] xxxiv, 77.
- Fatty.—On the fatty acid of the *Cocculus indicus* : by *W. Crowder*. *Phil. Mag.* [4] iv, 21.
- Preparation of pure fatty acids for the manufacture of candles. *Pharm. J. Trans.* xii, 137, 138.
- Organic.—Researches on the anhydrous organic acids : by *C. Gerhardt*. *Chem. Soc. Qu. J.* v, 127, 226 ; *Ann. Ch. Pharm.* lxxxii, 127 ; lxxxiii, 112 ; *Compt. rend.* xxxiv, 755, 902.
- On anhydrous organic acids : by *L. Chiozza*. *Ann. Ch. Pharm.* lxxxiv, 105.
- Affinity.—On the relation between the density of chemical compounds and their solubility in water, together with a theory of elective affinity thence deduced : by *P. Kremers* (conclusion). *Pogg. Ann.* lxxxv, 246.
- Agarics.—Poisonous agarics ; method of removing the poisonous principle. *J. Pharm.* [3] xxi, 155.
- Air.—Researches on the composition of atmospheric air : by *V. Regnault*. *Compt. rend.* xxxiv, 863.
- On the extraction of oxygen gas from atmospheric air : by *M. Boussingault*. *Ann. Ch. Phys.* [3] xxxv, 5 ; *abstr. Compt. rend.* xxx, 261 and 821 ; *Chem. Soc. Qu. J.* v, 269.
- On the composition of the air enclosed in vegetable mould : by *Boussingault* and *Lewy*. *Compt. rend.* xxxv, 765.
- Air-pump.—New construction of the air-pump, by which the injurious spaces are completely obviated : by *E. Schöhl*. *Pogg. Ann.* lxxxiv, 544.
- On a method of obtaining a perfect vacuum in the receiver of an air-pump : by *T. Andrews*. *Phil. Mag.* [4] iii, 161 ; *Chem. Soc. Qu. J.* v, 189.
- Albumin.—On albumin and casein : by *N. Lieberkühn*. *Pogg. Ann.* lxxxvi, 117, 298.
- On the combination of arsenious acid with albumin : by *Mr. Herapath*. *J. Pharm.* [3] xxi, 35.
- Causes of the passage of albumin into the urine : by *E. Robin*. *Compt. rend.* xxxiii, 698.
- On paralbumin and metalbumin : by *J. Scherer*. *Ann. Ch. Pharm.* lxxxii, 135.

- Alcohol.—On the action of a red heat on alcohol and acetic acid : by *M. Berthelot*. Ann. Ch. Pharm. lxxxi, 108.
- On the dehydration of alcohol : by *A. Gorgeu*. Compt. rend. xxxiii, 690 ; J. Pharm. [3] xxi, 259.
- On the action exerted by acids, by heat, and by alkaline and earthy chlorides on oil of turpentine and its hydrate, on sugar and on alcohol : by *M. Berthelot*. Compt. rend. xxxiv, 799 ; Ann. Ch. Pharm. lxxxiii, 107.
- On butylic alcohol : by *A. Wurtz*. Compt. rend. xxxv, 310 ; Chem. Gaz. 1852, 386.
- Aldehyde-ammonia.—Formation of oxalic ether and oxamide by the distillation of aldehyde-ammonia : by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 330.
- Ale.—Report on the alleged adulteration of pale ales by strychnine : by *Profs. Graham and Hofmann*. Chem. Soc. Qu. J. v, 173 ; Ann. Ch. Pharm. lxxxiii, 39.
- Algæ.—Examination of the seaweeds of the coasts of Lower Normandy : by *J. Pierre*. Compt. rend. xxxiv, 107.
- Alkalies.—Indirect method of determining magnesia and the alkalies when they occur together : by *K. List*. Ann. Ch. Pharm. lxxxi, 117.
- Formation of the ethylic alkalies by means of chloride of ammonium : by *M. Berthelot*. Compt. rend. xxxiv, 802.
- On the compounds of cotton with the alkalies : by *J. H. Gladstone*. Chem. Soc. Qu. J. v, 17.
- Alkaloids.—On a general method of detecting organic alkaloids in cases of poisoning : by *Prof. Stas*. J. Pharm. [3] xxii, 281 ; Pharm. J. Trans. xii, 195 ; Chem. Gaz. 1852, 348.
- Contribution to the chemical history of the mercury-compounds of the alkaloids : by *Fr. Hinterberger*. Ann. Ch. Pharm. lxxxii, 311.
- On the quantity of alkaloids contained in many cinchona barks : by *E. Riegel*. Pharm. J. Trans. xii, 258.
- On the combinations of the vegetable alkaloids with tartaric acid : by *M. Arppe*. J. pr. Chem. li, 331 ; Chem. Gaz. 1852, 9.
- On the mercurial compounds of the alkaloids : by *Dr. Hinterberger*. Sitzungsber der Akad. der Wissensch. zu Wien. vii, Heft. 3 ; Chem. Gaz. 1852, 422, 444.
- Allotropy.—On the allotropy of selenium : by *W. Hittorff*. Pogg. Ann. lxxxiv, 214 ; abstr. Phil. Mag. [4] iii, 546 ; Chem. Soc. Qu. J. v, 90.
- Alloy.—Analysis of a new alloy for the plates of calico-printers : by *C. Fischer*. J. pr. Chem. lv, 192 ; Chem. Gaz. 1852, 279.
- Alloys.—Memoir on alloys considered with relation to their chemical composition : by *A. Levol*. Ann. Ch. Phys. [3] xxxvi, 193.
- On the position of alloys and amalgams in the thermo-electric tension-series : by *W. Rollmann*. Pogg. Ann. lxxxiv, 275.
- On an alloy of potassium and sodium : by *R. Wagner*. J. pr. Chem. lv, 489 ; Ann. Ch. Phys. [3] xxxvi, 246.
- Note on a new alloy of silver : by *G. Barruel*. Compt. rend. xxxv, 759.
- Aloes.—On Socotrine aloë-juice, or liquid Socotrine aloes : by *J. Pereira*. Pharm. J. Trans. xi, 439.

- Aloine.**—On aloine, the crystalline cathartic principle of Barbadoes aloes: by *J. Steunhouse*. Pharm. J. Trans. xi, 458; J. Pharm. [3] xxi, 427.
- Alum.**—Application of the slag of blast-furnaces to the preparation of alum, chloride of calcium, &c. Pharm. J. Trans. xii, 259.
- Alumina.**—Alumina in *Lycopodium Chamæcyparissus*, and *L. clavatum*: by *A. Aderholdt*. Ann. Ch. Pharm. lxxxii, 111.
- On the preparation of sulphate of alumina: by *MM. Huria* and *Brunel*. Bull. Soc. d'Encourag. 1852, 199; Chem. Gaz. 1852, 359.
- 'Amazon.'**—Chemical report on the cause of the fire in the 'Amazon': by *T. Graham*. Chem. Soc. Qu. J. v, 534.
- Amides.**—On the combinations of certain amides: by *V. Dessaignes*. Ann. Ch. Pharm. lxxxii, 231; Compt. rend. xxxiii, 712; Ann. Ch. Phys. [3] xxxiv, 143.
- Ammonia.**—Easy decomposition of ammonia. New source of pure hydrogen for the reduction of metallic oxides: by *M. Bouet-Bonfil*. Ann. Ch. Phys. [3] xxxvi, 225; Compt. rend. xxxiv, 588.
- On the oxidation of ammonia in the human body, with some remarks on nitrification: by *H. Benze Jones*. Phil. Trans. 1851, ii, 399; Ann. Ch. Phys. [3] xxxv, 176.
- Presence of ammonia in hail: by *C. Mène*. Pogg. Ann. lxxxiv, 234.
- Influence of ammonia added to the air, on the development of plants: by *M. Ville*. Compt. rend. xxxv, 650.
- On a new reagent for ammonia, and a method for its quantitative estimation: by *F. L. Sonnenschein*. J. pr. Chem. lvi, 302; Chem. Gaz. 1852, 414.
- Action of ammonia on sebatic ether: by *T. H. Rowney*. Ann. Ch. Phys. [3] xxxv, 478.
- On the action of ammonia on bioxysulphocarbonate of amyl: by *M. W. Johnson*. Chem. Soc. Qu. J. v, 142.
- Improvements in obtaining ammoniacal salts (Newton's patent). Pharm. J. Trans. xii, 258.
- On neutral molybdate of ammonia: by *F. A. Flückiger*. Pogg. Ann. lxxxvi, 594.
- On the composition and crystalline form of the carbonates of ammonia: by *H. Ste-Claire Deville*. Compt. rend. xxxiv, 880.
- On the compound ammonias and the bodies of the cacodyl-series: by *T. S. Hunt*. Sill. Am. J. [2] xiii, 206; Phil. Mag. [4] iii, 392.
- Occurrence of rhodanhydric acid in a sample of commercial ammonia: by *M. Mazade*. Compt. rend. xxxv, 303.
- Amygdaline.**—Further experiments on the occurrence of amygdaline: by *W. Wicke*. Ann. Ch. Pharm. lxxxii, 241.
- Amyl.**—On the action of ammonia on bioxysulphocarbonate of amyl: by *M. W. Johnson*. Chem. Soc. Qu. J. v, 142.
- Note on the preparation of carbonate of amyl: by *J. A. Bruce*. Chem. Soc. Qu. J. v, 131.
- Amylamine.**—Action of amylamine on the animal economy: by *A. F. Orfila*. Compt. rend. xxxiv, 97.
- Amylum.**—On the amyllum grains of the potatoe: by *A. Martin*. Phil. Mag. [4] iii, 277.

- Analysis.**—On a new general method of separating bodies which resemble each other very closely in their properties : by *W. Heintz*. Pogg. Ann. lxxxiv, 221 ; *abstr.* Chem. Soc. Qu. J. v, 73.
- On some new general processes of chemical analysis : by *H. Ste-Claire Deville*. Compt. rend. xxxv, 242.
- Application of metallic reduction in the wet way to qualitative analysis : by *Prof. Fischer*. J. pr. Chem. liv, 347, 357 ; Chem. Gaz. 1852, 172.
- Contributions to analytical chemistry : by *Wolcott Gibbs*. Sill. Am. J. [2] xiv, 204 ; Chem. Gaz. 1852, 368.
- Anæsthetic Agents.**—Method of composing anæsthetic agents : by *E. Robin*. Compt. rend. xxxiv, 839.
- Animal Charcoal.**—On the animal charcoal obtained as a residue in refineries ; on its nature, mode of action on vegetables, its use in agriculture, and the economical advantages expected to result therefrom : by *A. de Romanet*. Compt. rend. xxxiv, 20, 388.
- On the variations observed in the use of animal charcoal in agriculture : by *A. Bobierre*. Compt. rend. xxxv, 790.
- Animal Chemistry.**—Contributions to animal chemistry.—Paper V. On the oxidation of ammonia in the human body, with remarks on nitrification : by *H. Bence Jones*. Phil. Trans. 1851, ii, 399.
- Animal Economy.**—On the metamorphoses which organic bodies undergo in the animal economy : by *M. Ranke*. J. pr. Chem. lvi, 1 ; J. Pharm. [3] xxii, 228.
- Animal Fluids.**—On the triple or ammonio-magnesian phosphates occurring in the urine and other animal fluids : by *J. W. Griffith*. Phil. Mag. [4] iii, 373.
- Animal Substances.**—Products of decomposition obtained by treating feathers, hedgehog's bristles, hairs, globulin, hæmatin, and the wing-cases of cockchafers with dilute sulphuric acid : by *A. C. Loyer* and *Köller*. Ann. Ch. Pharm. lxxxiii, 332.
- On the products of the destructive distillation of animal substances : by *T. Anderson*. Chem. Soc. Qu. J. v, 50.
- On the use of chloride of baryta for the preservation of animal substances : by *M. Blandet*. Compt. rend. xxxv, 221.
- On the preservation of animal and vegetable substances : by *Gail Borden, jun.* Chem. Gaz. 1852, 179.
- Anise.**—On anisated balsam of sulphur : by *E. Robiquet*. J. Pharm. [3] xxi, 200.
- Antimony.**—On some compounds of antimonious acid with bases : by *L. Heffter*. Pogg. Ann. lxxxvi, 418.
- On the salts of antimonious acid : by *L. Heffter*. Berl. Monatsbericht. 1852. 344 ; Phil. Mag. [4] iv, 399.
- Organic bases containing antimony. Chem. Soc. Qu. J. v, 66.
- On stibmethylum and its compounds : by *H. S. Landolt*. Chem. Gaz. 1852, 381, 404.
- On the fluorine-salts of antimony : by *F. A. Flückiger*. Pogg. Ann. lxxxvii, 245.
- For the modes of distinguishing antimony from arsenic, *vide* Arsenic.

- Arctostaphylos*.—On the leaves of *Arctostaphylos uva ursi*: by *A. Kawalier*. Ann. Ch. Pharm. lxxxii, 241; Pharm. J. Trans. xii, 195.
- Arsenic.—Note on chloride of arsenic: by *F. Penny* and *W. Wallace*. Phil. Mag. J. [4] iv, 361.
- On arseniate of protoxide of cobalt: by *M. Gentile*. J. pr. Chem. liv, 185; Chem. Gaz. 1852, 111.
- On the composition of arseniate of soda: by *R. Fresenius*. J. pr. Chem. lvii, 30; J. Pharm. [3] xxii, 226.
- Note on some new arsenites: by *M. Girard*. Compt. rend. xxxiv, 913.
- Presence of arsenic and antimony in various combustible minerals and rocks, and in sea-water: by *A. Daubrée*. Pogg. Ann. lxxxiv, 302.
- Improvement in Marsh's apparatus: by *M. Chodzko*. Ann. Ch. Phys. [3] xxxv, 206.
- On the detection and qualitative separation of tin, arsenic and antimony; and on the relation existing between these metals and others which are precipitated from their acid solutions by sulphuretted hydrogen: by *C. L. Bloxam*. Chem. Soc. Qu. J. v, 104; Ann. Ch. Pharm. lxxxiii, 180.
- On the qualitative separation of arsenic, tin and antimony: by *G. F. Ansell*. Chem. Soc. Qu. J. v, 210.
- On some distinguishing reactions of arsenical and antimonial spots: by *Prof. Wackenroder*. Arch. Pharm. [2] lxx, 14; Chem. Gaz. 1852, 298.
- Distinction between antimonial and arsenical spots: by *Mr. Slater*. Arch. Pharm. [2] lxx, 40; J. Pharm. [3] xxii, 316.
- New process for separating arsenic from organic substances: by *Schneider*. Pogg. Ann. lxxxv, 433.
- On the hydrated peroxide of iron and magnesia as antidotes in poisoning with arsenic: by *J. Haidlen*. Chem. Gaz. 1852, 169.
- Ash.—Analysis of a saline ash from British Guiana: by *E. Greaves*. Pharm. J. Trans. xi, 485.
- Ashes.—On the inorganic constituents of *Lycopodium Chamæcyparissus* and *L. clavatum*, with particular reference to the alumina which they contain: by *A. Aderholdt*. Ann. Ch. Pharm. lxxxii, 111.
- Analysis of the ashes of the Scotch fir (*Pinus sylvestris*) and the beech, with particular reference to the successive growth of different kinds of wood: by *G. Heyer*. Ann. Ch. Pharm. lxxxii, 180.
- On the inorganic constituents of the vine: by *Berthier*. Ann. Ch. Phys. [3] xxxiii, 249; Ann. Ch. Pharm. lxxxii, 133.
- Analysis of the ashes of the human brain: by *D. Breed*. Ann. Ch. Pharm. lxxx, 124.
- Analysis of the ashes of salt beef and ham: by *C. Thiel*. Ann. Ch. Pharm. lxxxi, 370.
- Analysis of the ash of unsalted pork: by *Echevarria*. Ann. Ch. Pharm. lxxx, 375.
- On the constituents of the ashes of the blood of *Limulus cyclops* (King's crab): by *F. A. Genth*. Ann. Ch. Pharm. lxxxi, 68.
- Asperula*.—Examination of the herb of *Asperula odorata*: by *R. Schwartz*. Chem. Gaz. 1852, 61.

- Aspirator.—On a new aspirator : by *T. Andrews*. Phil. Mag. [4] iv, 330.
- Atmosphere.—New process for determining the amount of water in the atmosphere : by *T. Andrews*. Pogg. Ann. lxxxv, 36.
- Researches on the constitution of the atmosphere : by *M. Lewy*. Ann. Ch. Phys. [3] xxxiv, 5.
- On the production of cyanogen by means of the nitrogen of the atmosphere : by *M. Rieken*. J. Pharm. [3] xxi, 29.
- On the quantity of carbonic acid in the higher regions of the atmosphere : by *A. Schlagintweit*. Pogg. Ann. lxxxvii, 693.
- Atomic Volume.—On the atomic volumes of bodies ; determination of these volumes in liquids : by *M. Avogadro*. Ann. Ch. Phys. [3] xxxvi, 96.
- Atomic Weight.—Researches on the relation between the mean atomic weight of elementary bodies and their specific heat : by *C. Garnier*. Compt. rend. xxxv, 278.—Remarks on the preceding : by *M. Wertheim*. Ibid. 300.
- Atomic Weights.—Observations on the atomic weights of elementary substances : by *O. L. Erdmann*. Ann. Ch. Pharm. lxxxii, 66.
- Atoms.—Seventh memoir on the grouping of atoms in molecules, and on the most intimate causes of crystalline form : by *A. Gaudin*. Compt. rend. xxxiv, 168.
- Attraction.—Note on molecular attraction : by *M. d'Estocquois*. Compt. rend. xxxiv, 475.

B.

- Barium.—On the atomic weights of platinum and barium : by *T. Andrews*. Chem. Gaz. 1852, 379.
- On the preparation of pure barium-compounds : by *H. Wurtz*. Chem. Gaz. 1852, 268.
- Bark.—On the *Cortex Soyimida*, the bark of *Swietenia febrifuga* : by *A. Overbeck*. Pharm. J. Trans. xi, 420.
- Yellow bark : by *Dr. Schwartz*. Pharm. J. Trans. xii, 17.
- Barley.—On the variation in the relative proportion of potash and soda in certain samples of barley, grown in plots of ground artificially impregnated with one or other of those alkalies : by *C. Daubeny*. Chem. Soc. Qu. J. v, 9.
- Experiments on the growth of barley in artificial soils : by *W. Henneberg*. Ann. Ch. Pharm. lxxxi, 355.
- Barometer.—On a necessary correction in the observed height of the barometer depending on the force of the wind : by *Capt. H. James*. Ed. Phil. Trans. xx, pt. 3, 377 : Proc. Roy. Soc. Edinb., 1851-2, 124.
- Baryta.—Action of baryta and strontia on the compounds of titanium before the blow-pipe : by *E. J. Chapman*. Chem. Gaz. 1852, 297.
- On the use of chloride of baryta for the preservation of animal substances : by *M. Blandet*. Compt. rend. xxxv, 221.
- Reclamation of priority with reference to the preceding : by *E. Robin*. Compt. rend. xxxv, 329.
- On the compounds of boracic acid and water with baryta : by *H. Rose*. Pogg. Ann. lxxxvii, 1.

- Bat.—On the composition of the excrements of bats : by *M. Lecanu*. J. Pharm. [3] xxi, 276.
- Batrachians.—New observations on the poison contained in the cutaneous pustules of Batrachian reptiles : by *P. Gratiolet* and *S. Cloez*. Compt. rend. xxxiv, 729 ; J. Pharm. [3] xxii, 37.
- Beech.—Analysis of the ashes of the Scotch fir (*Pinus sylvestris*) and beech, with particular reference to the successive growth of different kinds of wood : by *G. Heyer*. Ann. Ch. Pharm. lxxxii, 180.
- Beef.—Analysis of the ashes of salt beef and of ham : by *C. Thiel*. Ann. Ch. Pharm. lxxxi, 370.
- Benzin.—On the uses of benzin : by *M. Collas*. Pharm. J. Trans. xi, 428.
- Benzoyl.—On certain new products derived from the benzoyl-series by the action of nitric acid : by *C. Bertagnini*. Ann. Ch. Phys. [3] xxxiii, 465.
- Berberine.—On the occurrence of berberine in the Columbo wood of Ceylon (*Menispermum fenestratum*) : by *J. D. Perrins*. Ann. Ch. Pharm. lxxxiii, 276 ; Phil. Mag. [4] iv, 99 ; Pharm. J. Trans. xii, 189.
- Bismethyl.—On bismethyl, a new compound radical containing bismuth : by *D. Breed*. Sill. Am. J. [2] xiii, 404 ; Ann. Ch. Pharm. lxxxii, 106 ; Ann. Ch. Phys. [3] xxxv, 479 ; Chem. Gaz. 1852, 201 ; Chem Soc. Qu. J. v, 71.
- Bismuth.—On a combination of sulphur, nickel and bismuth : by *G. Werther*. J. pr. Chem. lv, 227 ; Chem. Gaz. 1852, 253.
- Bixine.—On bixine, a new dye-stuff : by *M. Girardin*. J. Pharm. [3] xxi, 174.
- Blacking.—Composition of blacking : Pharm. J. Trans. xii, 256.
- Bleaching.—On the indirect bleaching power of mercury : by *C. F. Schönbein*. J. pr. Chem. lvi, 353 ; Phil. Mag. [4] iv, 238.
- Blood.—Analysis of the venous blood of a horse, before and after the section of the pneumogastric nerves : by *M. Clement*. Compt. rend. xxxiv, 977.
- Chemical researches on the fatty matters in the venous blood of man : by *M. Gobley*. J. Pharm. [3] xxi, 241.
- Comparative analyses of the blood of the *vena porta* and the hepatic veins : by *M. Lehmann*. J. Pharm. [3] xxi, 396 ; J. pr. Chem. liii, 205.
- New chemical researches on the blood : by *M. Lecanu*. J. Pharm. [3] xxii, 244.
- Report on the preceding : by *M. Thénard*. Compt. rend. xxxv, 207.— Additional note on the same. Ibid. 273.
- On the colouring matter of the blood : by *F. Verdeil*. Compt. rend. xxxiii, 689.
- On the crystallization of one of the substances contained in blood-globules : by *MM. Funke* and *Lehmann*. Ann. Ch. Phys. [3] xxxvi, 244.
- On the crystallizability of one of the principal constituents of the blood-corpuscles : by *Prof. Lehmann*. J. pr. Chem. lv, 65 ; Chem. Gaz. 1852, 273 ; J. Pharm. [3] xxii, 157.
- On the crystallization of blood : by *M. Funke*. J. pr. Chem. lvi, 193 ; J. Pharm. [3] xxii, 156.

- Blood.—On the form in which the absorbed oxygen exists in the blood: by *J. Liebig*. *J. Pharm.* [3] xxi, 387.
- On the increase in the proportion of fibrin in the blood quite independently of phlegmasia: by *M. Hatin*. *Compt. rend.* xxxiv, 982.
- Origin of fibrin; mode of separating the blood-globules from the serous liquid which holds them in suspension in the living blood; analysis of the blood-globules: by *M. Lecanu*. *Compt. rend.* xxxv, 11.
- On the constituents of the ashes of the blood of *Limulus cyclops* (King's crab): by *F. A. Genth*. *Ann. Ch. Pharm.* lxxxi, 68.
- What is the chemical substance which determines the absorption of the oxygen contained in the blood, and how may the colouring of that liquid be accounted for? by *F. Hétet*. *Compt. rend.* xxxiv, 410.
- Bog-Butter.—On Irish bog-butter: by *J. A. Brazier*. *Chem. Gaz.* 1852, 375.
- Boiler.—Researches on the incrustation of boilers fed with sea-water: by *M. Couste*. *Compt. rend.* xxxv, 186.
- Brain.—Analysis of the ashes of the human brain: by *Dr. Breed*. *Ann. Ch. Pharm.* lxxx, 124.
- Bread.—Examination of bread to determine the percentage of bran: by *MM. Wetzel* and *Van Hees*. *Arch. Pharm.* [2] lxviii, 284; *Chem. Gaz.* 1852, 111.
- Experiments to determine the cause of the difference between new and stale bread: by *M. Boussingault*. *Compt. rend.* xxxv, 588.—Observations on the same: by *M. Thénard*. *Ibid.* 591.—By *M. Payen*. *Ibid.* 591.
- Bromine.—Observations on the presence of iodine and bromine in aliments and secretions: by *M. Grange*. *Compt. rend.* xxxiv, 332.
- Method of separating bromine and iodine, and of determining their ratio when mixed: by *O. Henry*. *J. Pharm.* [3] xxi, 255.
- Bronze.—Researches on the alteration of bronze used for the sheathing of ships: by *M. Bobierre*. *Compt. rend.* xxxiv, 688.
- Butyl.—On butylic alcohol: by *A. Wurtz*. *Compt. rend.* xxxv, 310; *Chem. Gaz.* 1852, 386.

C.

- Cacodyl.—On the compound ammonias and the bodies of the cacodyl-series: by *T. S. Hunt*. *Sill. Am. J.* [2] xiii, 206; *Phil. Mag.* [4] iii, 392.
- Cadmium.—On the compounds of the oxides of cadmium and silver with carbonic acid: by *H. Rose*. *Chem. Gaz.* 1852, 181.
- On the compounds of carbonic acid and water with oxide of cadmium: by *H. Rose*. *Pogg. Ann.* lxxxv, 304.
- On the medicinal properties of sulphide of cadmium: by *A. Grimaud*. *Compt. rend.* xxxiv, 528.
- Caffeine.—On the preparation of caffeine; by *H. J. Versmann*. *Arch. Pharm.* lxviii, 148; *Chem. Gaz.* 1852, 67.
- Calcium.—Application of the slag of blast-furnaces to the preparation of alum, chloride of calcium, &c. *Pharm. J. Trans.* xii, 259.

Calluna.—On the substances contained in ling (*Calluna vulgaris*): by *F. Rochleder*. Sitzungsber. d. Akad. d. Wissensch. zu Wien, July, 1852; Chem. Gaz. 1852, 468.

Candles.—Preparation of pure fatty acids for the manufacture of candles. Pharm. J. Trans. xii, 137, 138.

— Improvements in chemically treating the wicks of wax candles (Smith's patent): Pharm. J. Trans. xii, 304.

Cantharidine.—Volatility and solubility of cantharidine: by *W. Procter, jun.* Pharm. J. Trans. xii, 287.

Caoutchouc.—On caoutchouc and gutta-percha: by *M. Payen*. Compt. rend. xxxiv, 2.

— Improvements in the manufacture of gutta-percha and caoutchouc: by *S. Moulton*. Chem. Gaz. 1852, 239.

— On various processes for working caoutchouc, and on the manufacture of sulphide of carbon: by *M. Girard*. Compt. rend. xxxv, 257.

— Extract from a memoir on the sulphuration of caoutchouc and on certain properties of sulphur: by *M. Payen*. Compt. rend. xxxiv, 453; J. Pharm. [3] xxi, 366.

— Vulcanization of caoutchouc: by *M. Payen*. Pharm. J. Trans. xii, 32.

Capparis.—Chemical examinations of the flower-buds of *Capparis spinosa*: by *Rochleder* and *Illasiwetz*. Sitzungsber. d. Akad. d. Wissensch. zu Wien, Jan. 1852; Ann. Ch. Pharm. lxxxii, 197; J. pr. Chem. lvi, 96; J. Pharm. [3] xxii, 159; Chem. Gaz. 1852, 257.

Carbon.—On the decolourizing action of carbon and various other bodies: by *E. Filhol*. Compt. rend. xxxiv, 247.

— On the manufacture of sulphide of carbon: by *M. Girard*. Compt. rend. xxxv, 257.

Carbonates.—On metallic carbonates and their compounds with the carbonates of ammonia and of the fixed alkalies: by *H. Ste-Claire Deville*. Ann. Ch. Phys. [3] xxxv, 385; Ann. Ch. Pharm. lxxxi, 330; Compt. rend. xxxiv, 330.

— On the carbonates and other salts: by *A. Laurent*. Ann. Ch. Phys. [3] xxxvi, 320.

— Note on the crystalline form of double carbonates: by *H. Ste-Claire Deville*. Ann. Ch. Phys. [3] xxxv, 460.

— On the composition and crystalline form of the carbonates of ammonia: by *H. Ste-Claire Deville*. Compt. rend. xxxiv, 880.

— On the chemical constitution of the hydrocarbonates of magnesia: by *T. Scheerer*. Pogg. Ann. lxxxvii, 87.

— On the manner in which plants assist in the deposition of carbonate of lime: by *R. Ludwig* and *G. Theobald*. Pogg. Ann. lxxxvii, 91, 143.

— Note on the preparation of carbonate of amyl: by *J. A. Bruce*. Chem. Soc. Qu. J. v, 131.

Carrot.—On the quantity of sugar in the carrot (*Daucus carota*), and its alcoholic and nutritive equivalents: by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 325.

Casein.—On albumin and casein: by *N. Lieberkühn*. Pogg. Ann. lxxxvi, 117, 298.

- Cassia*.—Note on the *Cassia fistula*: by *X. Landerer*. J. Pharm. [3] xxi, 301.
- Cellulose.—Action of chloride of zinc on cellulose: by *M. Barreswil*. J. Pharm. [3] xxi, 205.
- Cement.—Cement for mending china. Pharm. J. Trans. xi, 372.
- Cements.—Analysis of two cements from Athens and the Piræus: by *A. Pauli*. Ann. Ch. Pharm. lxxxiii, 93.
- Centrifugal Force.—On the application of centrifugal force in chemical laboratories: by *L. v. Babo*. Ann. Ch. Pharm. lxxxii, 301.
- Cerium.—Separation of the oxides of cerium from iron: by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 325.
- Cetyl.—Preliminary notice on certain compounds of the cetyl-series: by *F. Fridau*. Ann. Ch. Pharm. lxxx, 117.
- Contributions to the chemical history of the cetyl-series: by *F. Fridau*. Ann. Ch. Pharm. lxxxiii, 1.
- Charcoal.—Researches on the decolourizing power of charcoal, and of various other bodies: by *M. Filhol*. J. Pharm. [3] xxi, 416; Ann. Ch. Pharm. lxxxii, 330.
- On the temperature produced by burning charcoal in the air: by *H. Ste-Claire Deville*. Compt. rend. xxxv, 796.
- Chemical Action.—Researches on the quantities of heat disengaged in chemical and molecular actions: by *P. A. Favre* and *J. T. Silbermann*. Ann. Ch. Phys. [3] xxxiv 385; xxxvi, 5.
- Chemical Affinity.—On the relation between the density of chemical compounds and their solubility in water, together with a theory of chemical affinity thence deduced: by *P. Kremers*. Pogg. Ann. lxxxv, 37.
- Researches on chemical affinity: by *M. Bunsen* (1st part). Compt. rend. xxxv, 834.
- Chemical Combination.—On the heat of chemical combination: by *Dr. Woods*. Phil. Mag. [4] iii, 299.
- On chemical combination, and on the amount of heat produced by the combination of several metals with oxygen: by *Dr. Woods*. Phil. Mag. [4] iv, 370.
- On the heat disengaged in chemical combination: by *J. P. Joule*. Phil. Mag. [4] iii, 481.
- Chemical Decomposition.—On the spontaneous decomposition of chemical compounds: by *H. Debus*. Ann. Ch. Pharm. lxxxii, 284.
- Chemical Memoranda by *R. Warington*. Chem. Soc. Qu. J. v, 136.
- i. On a curious form of crystallization of iodide of potassium, p. 136.
 - ii. On a method of detecting, qualitatively, small quantities of oxide of copper in solution, p. 137.
 - iii. Some additional observations on the green teas of commerce, p. 139.
 - iv. A modification of the ordinary process of sublimation in a straight tube, p. 141.
- Chemistry.—Early Egyptian chemistry: by *W. Herapath*. Phil. Mag. J. [4] iii, 528.—Also by *J. D. Smith*. Ibid. iv, 142.

- Chlorides.**—Observations on a new series of double chlorides containing diphtosammonium: by *G. B. Buckton*. Chem. Soc. Qu. J. v, 213.
- Note on chloride of arsenic: by *F. Penny* and *W. Wallace*. Phil. Mag. [4] iv, 361.
- On the conversion of alkaline sulphates into chlorides: by *H. Rose*. Pogg. Ann. lxxxv, 443.
- On a new compound of the highest chloride of sulphur with sulphuric acid: by *H. Rose*. Pogg. Ann. lxxxv, 510.
- Action of the chlorides of the alkali- and earth-metals on oil of turpentine, hydrate of turpentine, sugar and alcohol: by *M. Berthelot*. Ann. Ch. Pharm. lxxxiii, 104.
- Chlorine.**—On the use of chloride of baryta for the preservation of animal substances: by *M. Blandet*. Compt. rend. xxxv, 221.
- Examination of manganese and chloride of lime with regard to the amounts of peroxide of manganese and active chlorine contained in them: by *L. Müller*. Ann. Ch. Pharm. lxxx, 106; Chem. Gaz. 1852, 75.
- On the substitution-products formed by the action of chlorine on chloride of ethyl, and on a new pharmaceutical preparation thence resulting: by *A. Wiggers*. Ann. Ch. Pharm. lxxxii, 217.
- Influence of moist chlorine in the treatment of diabetes: by *A. Bobierre*. Compt. rend. xxxiv, 115.
- On the use of chlorine as an antidote to strychnine: by *M. Blandet*. Ann. Ch. Phys. [3] xxxv, 464.
- Chloroform.**—Note on the production of chloroform by means of chloride of lime and essence of turpentine: by *J. Chautard*. Compt. rend. xxxiii, 671.
- Action of sulphuretted and seleniuretted hydrogen on chloroform in presence of water: by *M. Leir*. J. Pharm. [3] xxi, 415; Compt. rend. xxxiv, 547.
- On a remarkable specimen of decomposed chloroform: by *J. Pereira*. Pharm. J. Trans. xi, 296.
- Chlorophyll.**—Note on the identity of a colouring matter existing in several animals, with the chlorophyll of plants: by *M. Schultze*. Compt. rend. xxxiv, 683.
- Chlorosulphalic Compounds.**—On uric, chlorosulphalic and percarbonic compounds: by *A. Laurent*. Compt. rend. xxxv, 629.
- Chlorosulphides.**—On the ammoniacal chlorosulphides: by *A. Laurent*. Ann. Ch. Phys. [3] xxxvi, 320.
- Chondrin.**—On chondrin and some of its products of decomposition: by *F. Hoppe*. J. pr. Chem. lvi, 129; J. Pharm. [3] xxii, 232.
- Chromium.**—A new method for the analysis of chrome ores: by *F. C. Calvert*. Chem. Soc. Qu. J. v, 194.
- On oxide of chromium crystallized in the dry way: by *M. Gentele*. J. pr. Chem. liv, 185; Chem. Gaz. 1852, 111.
- On the double-salt of chromate of potash and cyanide of mercury: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 145.
- Chufa.**—On the chemical nature of chufa (*Cyperus esculentus*): by *Ramon Luna*. Ann. Ch. Phys. [3] xxxv, 194.

- Cinchona*.—On *Cinchona rubra* and *C. sasanilla*: by *J. Batka*. Pharm. J. Trans. xi, 323.
- Examination of the bark of *Cinchona regia*: by *R. Schwartz*. Chem. Gaz. 1852, 208.
- On the quantity of alkaloids contained in many cinchona barks: by *E. Riegel*. Pharm. J. Trans. xii, 248.
- Clay.—On the causes of the agricultural efficacy of burnt clay: by *A. Völcker*. Chem. Gaz. 1852, 121.
- Coal.—Examination and analysis of the Ball coal of the Burdwan mines: by *H. Piddington*. Sill. Am. J. [2] xiii, 118.
- On the formation of coal: by *Göppert*. Pogg. Ann. lxxxvi, 482.
- On the resinous nature of coal: Sill. Am. J. [2] xiv, 70.
- Description and classification of the coals of the Loire: by *M. Diday*. Ann. Min. [5] ii, 115.
- Cobalt.—Researches on cobalt: by *E. Fremy*. Ann. Ch. Phys. [3] xxxv, 257; Compt. rend. xxxiv, 198; Ann. Ch. Pharm. lxxxiii, 227, 289.
- On arseniate of protoxide of cobalt: by *M. Gentile*. J. pr. Chem. liv, 185; Chem. Gaz. 1852, 111.
- On a class of ammoniacal compounds of cobalt: by *F. Claudet*. Ann. Ch. Phys. [3] xxxiii, 483.
- On some new compounds of cobalt: by *M. Rogoyski*. Compt. rend. xxxiv, 187.
- Compounds of carbonic acid and water with sesquioxide of cobalt: by *H. Rose*. Pogg. Ann. lxxxiv, 547; Chem. Gaz. 1852, 132.
- On the separation of nickel and cobalt: by *J. D. Smith*. Chem. Gaz. 1852, 259.
- Researches on a new compound of cobalt: by *E. St. Evre*. Compt. rend. xxxv, 552.
- On the super-oxygenated ammoniacal salts of cobalt: by *E. Fremy*. Ann. Ch. Phys. [3] xxxiv, 90.
- On Carrollite, a new cobalt-mineral: by *W. L. Faber*. Sill. Am. J. [2] xiii, 418.
- On Remingtonite, a new cobalt-mineral: by *J. C. Booth*. Sill. Am. J. [2] xiv, 48.
- On the detection of nickel and cobalt in the mineral waters of Nérac: by *M. Mazade*. Compt. rend. xxxiv, 479.
- Cocculus indicus*.—On the fatty acid of the *Cocculus indicus*: by *W. Crowder*. Phil. Mag. [4] iv, 21; Proc. Roy. Soc. Edinb. 1851-2, 107.
- Cochineal.—Note on a cochineal indigenous in the south of France: by *E. Chevreul*. Compt. rend. xxxiv, 701.
- Cocinone.—On cocinone: by *W. Delffs*. Pogg. Ann. lxxxvi, 587.
- Cocoa-nut.—Analysis of the liquid in a cocoa-nut: by *W. von Löwenich*. Pharm. J. Trans. xi, 513.
- Coffec.—On coffee-berries: by *Prof. Rochleder*. Ann. Ch. Pharm. lxxxii, 194; Chem. Gaz. 1852, 266.
- Coins.—Chemical examination of certain coins and weapons of the ancients: by *J. A. Phillips*. Ann. Ch. Pharm. lxxxii, 206.
- Coke.—On the preparation of coke for the manufacture of cast-iron: by *M. Calvert*. Compt. rend. xxxv, 433.

- Collodion.—Note on the use of collodion in photography: by *Mr. Bingham*. *Compt. rend.* xxxiv, 724.
- On elastic collodion: by *E. Lucas*. *Pharm. J. Trans.* xii, 303.
- Colouring Matter.—On the deportment of organic colouring matter towards sulphurous acid: by *C. F. Schönbein*. *J. pr. Chem.* liii, 321; *Chem. Gaz.* 1852, 15.
- Researches on the green colouring matter of plants, and on the red matter of the blood: by *F. Verdeil*. *Compt. rend.* xxxiii, 689.
- On bixine, a new dye-stuff: by *M. Girardin*. *J. Pharm.* [3] xxi, 174.
- On the colouring matters of fustic: by *R. Wagner*. *J. pr. Chem.* lv, 66; *Chem. Gaz.* 1852, 138.
- On a new yellow dyeing agent for silk and woollen, discovered by *M. Guinon* of Lyons: by *R. Warington*. *Chem. Gaz.* 1852, 270.
- On a green colouring matter from China: by *J. Persoz*. *Compt. rend.* xxxv, 558.
- On picric acid considered as a yellow colouring matter: by *M. Girardin*. *J. Pharm.* [3] xxi, 30; *Pharm. J. Trans.* xi, 373.
- On dyeing with sandal-wood: by *A. Wimmer*. *Chem. Gaz.* 1852, 235.
- On a green colouring matter from China: by *J. Persoz*. *Chem. Gaz.* 1852, 458.
- Colours.—On the chemical composition of certain fragments of colours, collected from the Arabian paintings of the 15th century, from the Alhambra at Granada: by *J. Persoz* and *E. Collomb*. *Compt. rend.* xxxiv, 544.
- Conicine.—New researches on conicine and its use in the cure of cancerous diseases: by *F. Devay*. *J. Pharm.* [3] xxii, 150.
- Copaiba.—Experiments on different sorts of copaiba: by *M. Guibourt*. *J. Pharm.* [3] xxii, 320.
- Copper.—Improvements in the manufacture of copper, and in the separation of some other metals therefrom, and in the production of the alloys of certain metals: by *A. Parkes*. *Chem. Gaz.* 1852, 218.
- On copper smelting: by *J. Napier*. *Phil. Mag.* [4] iv, 45, 192, 262, 345, 453.
- On the metallurgic treatment of the copper-schists of Mansfeld: by *M. Lan*. *Ann. Min.* [4] xx, 501.
- On a method of detecting, qualitatively, small quantities of oxide of copper in solution: by *R. Warington*. *Chem. Soc. Qu. J.* v, 137.
- Extraction of copper by ammonia: by *G. Barruel*. *Compt. rend.* xxxv, 18; *J. Pharm.* [3] xxii, 197.
- On the compounds of carbonic acid with oxide of copper: by *H. Rose*. *Chem. Gaz.* 1852, 28.
- On several new sulphites of cuprous oxide: by *L. Péan de St. Gilles*. *Ann. Ch. Phys.* [3] xxxvi, 80.
- On the corrosion of the tin cooling-tubes in copper coolers: by *F. A. Wolff*. *Ann. Ch. Pharm.* lxxxix, 374.
- Magnesia as an antidote to salts of copper: by *M. Roncha*. *Chem. Gaz.* 1852, 133.
- New mode of estimating copper by means of graduated solutions: by *H. Schwartz*. *Ann. Ch. Pharm.* lxxxiv, 84.
- Cotton.—On the compounds of cotton with the alkalis: by *J. H. Gladstone*. *Chem. Soc. Qu. J.* v, 17.

- Cotton.—Simple process for precipitating the cotton contained in collodion : by *T. Cattell*. *J. Frank. Inst.* [3] xxiii, 206.
- Crab.—On the constituents of the ashes of the blood of *Limulus cyclops* (King's crab) : by *F. A. Genth*. *Ann. Ch. Pharm.* lxxxi, 68.
- Creatine.—On the occurrence of creatine in calves' urine : by *N. Socoloff*. *Ann. Ch. Pharm.* lxxx, 114.
- Crystallization.—Method of crystallization by the aid of constant circulation : by *M. Payen*. *Compt. rend.* xxxiv, 578 ; *Pharm. J. Trans.* xii, 45.
- Crystalline Form.—New researches on the relations which may exist between crystalline form, chemical composition and molecular rotatory power : by *L. Pasteur*. *Compt. rend.* xxxv, 176.
- Seventh memoir on the grouping of atoms in molecules, and on the most intimate causes of crystalline form : by *A. Gaudin*. *Compt. rend.* xxxiv, 168.
- Contributions to the calculus of crystallography : by *J. H. T. Müller*. *Pogg. Ann.* lxxxiv, 539.
- Note on the crystalline form of double carbonates : by *H. Ste-Claire Deville*. *Ann. Ch. Phys.* [3] xxxv, 460.
- On lettering figures of crystals : by *J. D. Dana*. *Sill. Am. J.* [2] xiii, 399.
- Cyanides.—Action of water at a high temperature and under strong pressure, on the pyrophosphates, metaphosphates, cyanides, &c. : by *A. Reynoso*. *Compt. rend.* xxxiv, 795 ; *J. Pharm.* [3] xxi, 29 ; *J. Pharm.* [3] xxii, 14.
- Note on the commercial analysis of cyanide of potassium : by *J. Fordos* and *A. Gélis*. *Compt. rend.* xxxv, 224 ; *Pharm. J. Trans.* xii, 254.
- On certain double salts of cyanide of mercury : by *G. Kohl* and *A. Swobada*. *Ann. Ch. Pharm.* lxxxiii, 339.
- Observations on the double cyanide of potassium and silver, and on its function in electro-chemistry : by *H. Bouilhet*. *Ann. Ch. Phys.* [3] xxxiv, 153.
- On the double salt of chromate of potash with cyanide of mercury : by *C. Rammelsberg*. *Pogg. Ann.* lxxxv, 145.
- On the ammoniacal chlorosulphides and cyanides : by *A. Laurent*. *Ann. Ch. Phys.* [3] xxxvi, 320.
- Cyanogen.—On the production of cyanogen from the nitrogen of the atmosphere : by *M. Rieken*. *J. Pharm.* [3] xxi, 29.
- Cynoglossum.—On cynoglossum pills : by *M. Leconet*. *J. Pharm.* [3] xxii, 120.
- Cystic Oxide.—Examination of a cystic calculus and of cystic urine : by *J. Müller*. *Arch. Pharm.* [2] lxix, 328 ; *J. Pharm.* [3] xxii, 76.
- On cystic oxide calculi : by *A. and W. Knop*. *Arch. Pharm.* [2] lxix, 297, 328 ; *Chem. Gaz.* 1852, 292.

D.

- Density.—On the relation between the density of chemical compounds and their solubility in water, together with a theory of chemical affinity thence deduced : by *P. Kremers*. *Pogg. Ann.* lxxxv, 37, 246.
- Diamond.—On a remarkable property of the diamond : by *D. Brewster*. *Phil. Mag.* [4] iii, 284.

- Diabetes.—Influence of moist chlorine in the treatment of diabetes: by *A. Bobierre*. *Compt. rend.* xxxiv, 115.
- Dibenzoylimide.—On dibenzoylimide, a new derivative of oil of bitter almonds: by *J. H. Robson*. *Ann. Ch. Pharm.* lxxxi, 122.
- Diet.—An account of some experiments on the diet of prisoners: by *Prof. Christison*. *Proc. Roy. Soc. Edinb.* 1851-2, 130.
- Diffusion.—Additional observations on the diffusion of liquids: by *Thomas Graham*. *Phil. Trans.* 1851, ii, 483.
- Digitalis*.—On the seed and capsules of *Digitalis purpurea*: by *A. Buchner, sen.* *Buchn. Repert.* ix, 38; *Chem. Gaz.* 1852, 46; *Pharm. J. Trans.* xi, 419; *J. Pharm.* [3] xxi, 432.
- Diplatosammonium.—Observations on a new series of double chlorides containing diplatosammonium: by *G. B. Buckton*. *Chem. Soc. Qu. J.* v, 213.
- Disinfectants.—On chemical disinfectants: by *G. Wilson*. *Pharm. J. Trans.* xii, 278.
- Distillation.—On the products of the destructive distillation of animal substances: by *T. Anderson*. *Chem. Soc. Qu. J.* v, 50.
- Donarium.—Chemical researches on a new oxide obtained from a Norwegian mineral; examination and analysis of Orangite: by *A. Dumour*. *Compt. rend.* xxxiv, 685; *Ann. Min.* [5] i, 587.
- On thorina and donaria. *Pogg. Ann.* lxxxv, 555.
- On the new metal, *Donarium*. *Phil. Mag.* [4] iv, 156.
- Dyeing.—Preparation of cotton and other fabrics for dyeing and calico-printing (Mercer and Greenwood's patent): *Chem. Gaz.* 1852, 460.

E.

- Earths.—On the acid oxalates of the earths: by *E. Clapton*. *Chem. Soc. Qu. J.* v, 223.
- Edible earths: by *M. Ehrenberg*. *Pharm. J. Trans.* xii, 37.
- Elastic Tissue.—Contributions to the chemical history of elastic tissue: by *H. Zollikofer*. *Ann. Ch. Pharm.* lxxxii, 162; *abstr. Ann. Ch. Phys.* [3] xxxvi, 116; *J. Pharm.* [3] xxii, 234.
- Electricity.—Experimental researches in electricity: by *M. Faraday*. *Series* 24, 25, 26, 27. *Phil. Trans.* 1851, i, 1, 7, 29, 85.
- Experiments on electric currents: by *Th. du Moncel*. *Compt. rend.* xxxv, 518.
- On electric currents of the third and higher orders: by *P. Riess*. *Phil. Mag.* [4] iii, 173.
- On the law of galvanic currents: by *M. Despretz*. *Compt. rend.* xxxiv, 781.
- On the development of electricity in chemical combinations, and on the theory of circuits formed with one metal and two liquids: by *C. Matteucci*. *Ann. Ch. Phys.* [3] xxxiv, 281; *Compt. rend.* xxxiii, 663.
- On the so-called *constant* batteries: by *M. Despretz*. *Compt. rend.* xxxiv, 737; xxxv, 449.
- On the economical constant battery: by *C. G. Page*. *Sill. Am. J.* [2] xiii, 257.

- Electricity.—On the amalgamated zinc of constant batteries: by *M. Nicklès*. J. Pharm. [3] xxi, 266.
- New arrangement of the voltaic pile: by *Fabre de Lagrange*. Phil. Mag. [4] iv, 77; Compt. rend. xxxiv, 533.
- On gas-batteries, and on the preparation of hydrobromic and hydriodic acids by the galvanic method: by *G. Osann*. Phil. Mag. [4] iii, 317.
- On two modifications of Bunsen's battery, one of which increases the interior conductivity, and the other the tension: by *Liais and Fleury*. Compt. rend. xxxv, 802.
- Preliminary note on the measurement of the galvanic current by the decomposition of sulphate of copper: by *M. H. Jacobi*. Ann. Ch. Phys. [3] xxxiv, 480.
- Improvements in galvanic batteries, and useful applications resulting therefrom. Pharm. J. Trans. xii, 142.
- On electricity of contact: by *H. Buff*. Ann. Ch. Pharm. lxxxiii, 249.
- On the measurement of resistance of conductors to the passage of electric currents, and on a differential galvanometer: by *A. F. Svanberg*. Pogg. Ann. lxxxiv, 411.
- Observations on galvanic polarization: by *E. Edlund*. Pogg. Ann. lxxxv, 209.
- On the supposed identity of the agent concerned in the phenomena of ordinary electricity, voltaic electricity, electro-magnetism, magneto-electricity and thermo-electricity: by *M. Donovan*. Phil. Mag. [4] iii, 117, 198, 290, 335, 445; iv, 33, 210.
- Remarks on the researches of Dr. Goodman, "On the identity of the existences or forces, light, heat, electricity, and magnetism:" by *Dr. Tyndall*. Phil. Mag. [4] iii, 127.
- On the electroscopic properties of the voltaic current: by *Dr. Kohlrausch*. Phil. Mag. [4] iii, 321.
- Electro-chemical researches on the properties of electrified bodies: by *E. Fremy and E. Becquerel*. Ann. Ch. Phys. [3] xxxv, 62; *abstr.* Compt. rend. xxxiv, 399; J. Pharm. [3] xxi, 325; Phil. Mag. [4] iii, 543; Chem. Soc. Qu. J. v, 272.
- On the electro-chemical function of oxygen: by *M. Viard*. Ann. Ch. Phys. [3] xxxvi, 129.
- Observations on the electro-chemical properties of hydrogen: by *E. Becquerel*. Compt. rend. xxxv, 647.
- Preparation of magnesium by the electrolytic method: by *R. Bunsen*. Ann. Ch. Pharm. lxxxii, 137.
- On the supposed electrical conducting power of Marekanite: by *W. Hankel*. Pogg. Ann. lxxxvii, 67.
- Observations on the double cyanide of potassium and silver, and on its function in electro-chemistry: by *H. Bouilhet*. Ann. Ch. Phys. [3] xxxiv, 153.
- Experiments on the distribution and action of free electricity on and in conductors, together with indications of radiating electricity: by *E. Schöbl*. Pogg. Ann. lxxxiv, 267.

- Electricity.—On electrodynamic induction: by *R. Felici*. Ann. Ch. Phys. [3] xxxiv, 64.
- On the unequal heating effect of a galvanic current while entering and emerging from a conductor: by *R. Adie*. Phil. Mag. [4] iv, 224.
- On some thermo-electric experiments: by *R. Adie*. Phil. Mag. [4] iii, 185.
- On thermo-electric currents. Phil. Mag. [4] iii, 81.
- On the temperature of a bismuth and antimony joint during the passage of an electric current. Phil. Mag. [4] iv, 380.
- On the electrical properties of flanne: by *H. Buff*. Ann. Ch. Pharm. lxxx. 1; Phil. Mag. [4] iii, 145.
- On the position of alloys and amalgams in the thermo-electric tension-series: by *W. Rollmann*. Pogg. Ann. lxxxiv, 275.
- Note on galvanic plating: by *E. Thomas* and *V. Delisse*. Compt. rend. xxxiv, 556, 580; Chem. Gaz. 1852, 415,
- Facts relating to the history of galvanic plating: by *M. Bouilhel*. J. Pharm. [3] xxi, 44.
- On various electrical phenomena produced by a plate-machine improved by *M. Steiner*: by *M. Ducis*. Compt. rend. xxxiv, 208.
- On the reduction of temperatures by electricity: by *J. Tyndall*. Phil. Mag. [4] iv, 419.
- On the electro chemical polarity of gases: by *W. R. Grove*. Phil. Mag. [4] iv, 493.
- On the motion of fluids, from the positive to the negative pole of the closed galvanic circuit: by *M. Wiedemann*. Phil. Mag. [4] iv, 545.
- Elephant.—Examination of the fat and concretions found in the carcase of a female elephant: by *E. Filhol* and *N. Joly*. Compt. rend. xxxv, 379.
- Ergot.—On some new constituents of ergot of rye: by *F. L. Winckler*. Chem. Gaz. 1852, 38.
- Ergotine.—Preparation of propylamine from ergotine: by *F. L. Winckler*. Pharm. J. Trans. xii, 42.
- Ethalone.—On ethalone: by *R. Piria*. Ann. Ch. Pharm. lxxxii, 249.
- Ether, Hydrochloric.—Action of chlorine on hydrochloric ether: by *V. Regnault*. Pharm. J. Trans. xi, 411.
- On chlorinated hydrochloric ether: by *M. Mialhé*. Pharm. J. Trans. xi, 411.
- Lactic.—On lactic ether: by *A. Strecker*. Ann. Ch. Pharm. lxxxii, 247.
- Œnanthic.—On œnanthic ether and œnanthic acid: by *W. Delfs*. Pogg. Ann. lxxxiv, 505.
- Oxalic.—Formation of oxalic ether and oxamide in the distillation of aldehyde-ammonia: by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 330.
- Sebacic.—Action of ammonia on sebacic ether: by *T. H. Rowney*. Ann. Ch. Phys. [3] xxxv, 478.
- Succinic.—On the resin of jalap and on perchlorinated succinic ether: by *A. Laurent*. Compt. rend. xxxv, 379.
- Etherification.—On etherification: by *A. W. Williamson*. Ann. Ch. Pharm. [3] lxxxi, 73.
- On etherification by chloride of zinc. J. Pharm. [3] xxi, 357.

- Ethers.—Researches on a new class of ethers: by *G. Chancel*. *Ann. Ch. Phys.* [3] xxxv, 466.
- Ethyl.—On the formation of the ethyl-bases by chloride of ammonium: by *M. Berthelot*. *Ann. Ch. Pharm.* lxxxiii, 109.
- On bismethyl, a new organic radical containing bismuth: by *D. Breed*. *Sill. Am. J.* [2] xiii, 404; *Ann. Ch. Pharm.* lxxxii, 106; *Ann. Ch. Phys.* [3] xxxv, 479; *Chem. Gaz.* 1852, 201; *Chem. Soc. Qu. J.* v, 71.
- Researches on stannethyl, a new organic radical containing tin: by *A. Cahours* and *A. Riche*. *Compt. rend.* xxxv, 91.
- Observations on telluride of ethyl: by *W. Mallet*. *Chem. Soc. Qu. J.* v, 71.
- On some new compounds of tellurethyl: by *F. Wöhler*. *Ann. Ch. Pharm.* lxxxiv, 69.
- On ethyl-mercuric nitrate: by *C. Gerhardt*. *Ann. Ch. Pharm.* lxxx, 111; *Chem. Soc. Qu. J.* v, 88.
- On certain decomposition-products of bioxysulphocarbonate of ethyl, and on the spontaneous decomposition of chemical compounds: by *H. Debus*. *Ann. Ch. Pharm.* lxxxii, 253; *Ann. Ch. Phys.* [3] xxxvi, 231.
- Ethylamine.—On some new double salts of ethylamine and propylamine: by *M. Reckenschuss*. *Ann. Ch. Pharm.* lxxxiii, 343.
- Action of ethylamine on the animal economy: by *A. F. Orfila*. *Compt. rend.* xxxiv, 97.
- Excrements.—On the composition of the excrements of bats: by *M. Lecanu*. *J. Pharm.* [3] xxi, 276.
- Extracts.—Report presented to the “*Société de Pharmacie*” on extracts prepared in vacuo: by *MM. Robinet, Goble* and *Dublanc*. *J. Pharm.* [3] xxi, 185.

F.

- Fat.—On the composition of human fat: by *W. Heintz*. *Pogg. Ann.* lxxxiv, 238; *Chem. Soc. Qu. J.* v, 173; *Phil. Mag.* [3] iv, 75.
- On the development of fat in animals: by *M. Daniel*. *Compt. rend.* xxxiii, 670.
- Examination of the fat and concretions found in the carcase of a female elephant; by *E. Filhol* and *N. Joly*. *Compt. rend.* xxxv, 393.
- On the treatment of fat in the preparation of candles. *Pharm. J. Trans.* xi, 372.
- On certain isomeric transformations of fats: by *P. Duff*. *Chem. Soc. Qu. J.* v, 197; *Compt. rend.* xxxv, 284.
- On the fat of potatoes: by *H. Eichborn*. *Pogg. Ann.* lxxxvii, 227; *Chem. Gaz.* 1852, 461.
- Febrifuges.—Report addressed to the “*Société de Pharmacie*” on the new febrifuges proposed as substitutes for sulphate of quinine. *J. Pharm.* [3] xxi, 81.
- Fermentation.—Researches on gallic acid fermentation: by *E. Robiquet*. *J. Pharm.* [3] xxii, 129; *Chem. Gaz.* 1852, 297; *Compt. rend.* xxxv, 199.—Remarks on the above: by *M. Larocque*. *Ibid.* 221.
- Fibrin.—Origin of fibrin: by *M. Lecanu*. *Compt. rend.* xxxv, 11.
- On the form assumed by fibrin during inflammation: by *M. Blondot*. *Compt. rend.* xxxv, 99.

- Filtration.—Description of an accelerating filter : by *M. Dublanc*. J. Pharm. [3] xxi, 114.
- Fir.—Examination of the ashes of the Scotch fir (*Pinus sylvestris*) and the beech, with particular reference to the successive growth of different kinds of wood : by *G. Heyer*. Ann. Ch. Pharm. lxxxii, 180.
- Fire.—Chemical report on the cause of the fire in the ‘Amazon :’ by *T. Graham*. Chem. Soc. Qu. J. v, 34.
- Mixtures for coloured fires : by *Prof. Marchand*. J. pr. Chem. lv, 250 ; Chem. Gaz. 1852, 176.
- Flame.—On the electrical properties of flame : by *H. Buff*. Ann. Ch. Pharm. lxxx, 1 ; Phil. Mag. [4] iii, 145.
- Flax.—On the preparation of flax : by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 321.
- Flour.—On the processes proposed for detecting certain falsifications in flour : by *M. Biot*, of Namur. J. Pharm. [3] xxii, 184.
- On the detection of wheat-flour in rye-flour. Pogg. Ann. lxxxv, 145.
- Fluorine.—New process for the detection of fluorine when accompanied by silica : by *G. Wilson*. Chem. Soc. Qu. J. v, 152.
- On two new processes for the detection of fluorine when accompanied by silica ; and on the presence of fluorine in granite, trap, and other igneous rocks, and in the ashes of recent and fossil plants : by *G. Wilson*. Proc. Roy. Soc. Edinb. 1851-2, 143.
- On the presence of fluorine in plants, with some new observations on the sources from which vegetables derive this element : by *G. Wilson*. Proc. Bot. Soc. Edinb. July, 8, 1852 ; Chem. Gaz. 1852, 309.
- On the fluorine-salts of antimony : by *F. A. Flückiger*. Pogg. Ann. lxxxvii, 245.
- Food.—On the composition of food in relation to respiration and the feeding of animals : by *J. B. Laves* and *J. H. Gilbert*. Chem. Gaz. 1852, 398.
- Fuel.—On a new fuel called *Charbon de Paris* : by *P. Ducarre*. J. Frank. Inst. [3] xxiii, 284.
- Fusel-oil.—On the occurrence of capric and caprylic acids in some fusel-oils : by *T. H. Rowney*. Chem. Soc. Qu. J. v, 22.
- Fustic.—On the colouring matters of fustic : by *R. Wagner*. J. pr. Chem. lv, 66 ; Chem. Gaz. 1852, 138.

G.

- Galium.—Preliminary notice on the constituents of the herb of *Galium verum* and *Galium aparine* : by *R. Schwartz*. Ann. Ch. Pharm. lxxxiii, 57 ; Pharm. J. Trans. xii, 191.
- Gas.—Contributions to the knowledge of the gas-manufacture : by *E. Frankland*. Ann. Ch. Pharm. lxxxii, 1 ; abstr. Chem. Soc. Qu. J. v, 39.
- Improvements in the manufacture of gas. J. Frank. Inst. [3] xxiii, 120. 205.
- On the manufacture of gas from wood : by *Dr. Pettenkofer*. Centralblatt. Mar. 10, 1852 ; Chem. Gaz. 1852, 179.
- Gas-lamp for laboratory use : by *A. W. Hofmann*. Ann. Ch. Pharm. lxxxii, 226.
- On a gas-pipette : by *A. Pauli*. Ann. Ch. Pharm. lxxxiii, 95.

- Gases.—On the heating and cooling of gases by sudden change of volume: by *C. Assmann*. Pogg. Ann. lxxxv, 1.
- On the magnetic relations of gases: by *Plücker*. Pogg. Ann. lxxxiv, 161.
- On the electro-chemical polarity of gases: by *W. R. Grove*. Phil. Mag. [4] iv, 498.
- Gentian.—On the extract of gentian: by *Dr. Mohr*. Arch. Pharm. lxxviii, 145; Chem. Gaz. 1852, 108.
- Glass.—On auriferous glass: by *D. C. Splitberger*. Pogg. Ann. lxxxv, 504.
- On the crystals contained in glass: by *Leydolt*. Pogg. Ann. lxxxvi, 494.
- Note on crystals contained in glass. Compt. rend. xxxiv, 565.
- Glucosamides.—On tannins and glucosamides: by *A. Laurent*. Compt. rend. xxxv, 161.
- Glue.—On the preparation of liquid-glue. Chem. Gaz. 1852, 457.
- Gold.—Improvements in obtaining gold: by *W. Longmaid*. Chem. Gaz. 1852, 360.
- Improvements in separating gold and silver from other metals (Parkes' patent). Pharm. J. Trans. xii, 304.
- Grain.—Practical instruction on the steeping of grain: by *M. Payen*. J. Pharm. [3] xxi, 369.
- Grapes.—On the acid of unripe grapes: by *H. Schwartz*. Ann. Ch. Pharm. lxxxiv, 82.
- Gravities, Original.—Report upon "Original gravities:" by *Profs. Graham, Hofmann and Redwood*. Chem. Soc. Qu. J. v, 22; Pharm. J. Trans. xii, 160, 235.
- Guaiacum.—On guaiacum resin: by *L. E. Jones*. Pharm. J. Trans. xi, 523.
- Guimava.—Report on a new mode of preparing the syrup of guimava, proposed by *M. Duvivier*: by *M. Mayet*. J. Pharm. [3] xxii, 127.
- Gun-cotton.—Researches on gun-cotton (pyroxyline): by *A. Bechamp*. Compt. rend. xxxv, 473.
- On the spontaneous decomposition of gun-cotton and allied substances: by *J. H. Gladstone*. Pharm. J. Trans. xi, 401.
- Gutta Percha.—Improvements in the manufacture of gutta percha and caoutchouc: by *S. Moulton*. Chem. Gaz. 1852, 239.
- Extract from a memoir on gutta percha, its properties, ultimate analysis, &c.: by *M. Payen*. J. Pharm. [3] xxii, 172; Compt. rend. xxxv, 109; Chem. Gaz. 1852, 353.

H.

- Hæmatology.—Origin of fibrin. Method of separating the blood-globules from the serous liquid which holds them in suspension in the living blood. Analysis of the blood-globules: by *M. Lecanu*. Compt. rend. xxxv, 11.
- Hæmostatics.—On the hæmostatic water of *M. Pagliari*, and on some other hæmostatics: by *M. Sedillot*. J. Pharm. [3] xxi, 10.
- Hair.—Note on the microscopic appearances of human hair and of the hairs of animals: by *M. Morin*. J. Pharm. [3] xxii, 257.
- Ham.—Analysis of the ashes of salt-beef and ham: by *C. Thiel*. Ann. Ch. Pharm. lxxxi, 370.
- Heat.—Action of heat on oil of turpentine, hydrate of turpentine, sugar and alcohol: by *M. Berthelot*. Ann. Ch. Pharm. lxxxiii, 104.

- Heat.—Researches on the quantities of heat disengaged in chemical and molecular actions: by *P. A. Favre* and *J. T. Silbermann*. *Ann. Ch. Phys.* [3] xxxiv, 385; xxxvi, 5.
- On the heat disengaged in chemical combination: by *J. P. Joule*. *Phil. Mag.* [4] iii, 481.
- On the heat of chemical combination: by *Dr. Woods*. *Phil. Mag.* [4] iii, 299.
- On the amount of heat produced by the combination of several metals with oxygen: by *Dr. Woods*. *Phil. Mag.* [4] iv, 370.
- On the diffusion of heat: by *MM. Provostaye* and *Desains*. *Ann. Ch. Phys.* [3] xxxiv, 192.
- Second note on the theory of the dynamical effects of heat: by *M. Reech*. *Compt. rend.* xxxiv, 21.
- On the mechanical equivalent of heat: by *A. F. Kupffer*. *Pogg. Ann.* lxxxvi, 310; *Phil. Mag.* [4] iv, 393.
- On the expansion of certain solid bodies by heat: by *H. Köpp*. *Ann. Ch. Pharm.* lxxxi, 1, 156; *Phil. Mag.* [4] iii, 268.
- On thermometry and subjects therewith connected: by *Plücker* and *Geissler*. *Pogg. Ann.* lxxxvi, 238.
- On a new method of measuring high temperatures: by *J. Wilson*. *Phil. Mag.* [4] iv, 157.
- Researches on the latent heat of solution: by *C. C. Person*. *Ann. Ch. Phys.* [3] xxxiii, 448.
- Researches on the relation between the mean atomic weight of bodies and their specific heat: by *C. Garnier*. *Compt. rend.* xxxv, 278.—Remarks on the preceding: by *M. Wertheim*. *Ibid.* 300.
- Researches on the specific heat of saline solutions: by *C. C. Person*. *Ann. Ch. Phys.* [3] xxxiii, 437.
- On the temperature of a bismuth and antimony joint during the passage of an electric current: by *R. Adie*. *Phil. Mag.* [4] iv, 380.
- On the conductivity of metals for heat: by *H. J. Gouilland*. *Compt. rend.* xxxv, 699.
- On the heat produced by the combustion of charcoal in the air: by *H. Ste-Claire Deville*. *Compt. rend.* xxxv, 796.
- Note on the heat of chemical combination: by *T. Andrews*. *Phil. Mag.* [4] iv, 497.
- On the reduction of temperatures by electricity: by *J. Tyndall*. *Phil. Mag.* [4] iv, 419.
- Helix.—Analysis of the shell of *Helix pomatia*: by *C. A. Joy*. *Ann. Ch. Pharm.* lxxxii, 365.
- Hellebore.—Crystallized body from *Helleborus niger*: by *Mr. Bastick*. *Pharm. J. Trans.* xii, 274.
- Hemlock.—Researches on the principle of the hemlock, and its use in treating cancerous disorders: by *MM. Davy* and *Guillermont*. *J. Pharm.* [3] xxi, 350.
- Herrings.—On the occurrence of trimethylamine in herring-brine: by *A. W. Hofmann*. *Ann. Ch. Pharm.* lxxxiii, 116; *Compt. rend.* July 12, 1852; *Chem. Soc. Qu. J.* v, 288; *Chem. Gaz.* 1852, 296.
- Hippophaë.—Malic acid contained in *Hippophaë rhamnoides*: by *Prof. Erdmann*. *J. pr. Chem.* lv, 121; *Chem. Gaz.* 1852, 253.

- Hircine.**—On hircine, a new resin : by *H. Piddington*. Chem. Gaz. 1852, 213.
- Horse.**—On the organs in which lead accumulates in the horse in cases of slow poisoning by that metal : by *G. Wilson*. Proc. Roy. Soc. Edinb. 1851-2, 119.
- Humus.**—On the composition of the air contained in vegetable mould : by *Boussingault and Levy*. Compt. rend. xxxv, 765.
- Hydrogen.**—Easy decomposition of ammonia. New source of pure hydrogen for the reduction of metallic oxides : by *M. Bouet-Bonfil*. Ann. Ch. Phys. [3] xxxvi, 225 ; Compt. rend. xxxiv, 588.
- Observations on the electro-chemical properties of hydrogen : by *E. Becquerel*. Compt. rend. xxxv, 647.
- On M. Gillard's light for illumination obtained from hydrogen : by *B. Silliman, jun.* Phil. Mag. [4] iii, 152.
- Hypochlorites.**—Action of hypochlorite of lime on oil of turpentine and other essential oils : by *M. Chautard*. J. Pharm. [3] xxi, 88.

I.

- Incrustation.**—Note on incrustations in steam-boilers : by *M. Delandre*. Compt. rend. xxxiv, 484.
- Researches on the incrustation of steam-boilers fed with sea-water : by *M. Couste*. Compt. rend. xxxv, 186.
- Improvements in preventing the incrustation of steam-boilers (Newton's patent). Pharm. J. Trans. xii, 305.
- Indigo.**—Process for imparting greater liveliness to indigo-blue in stuffs : by *L. Guillonet*. Chem. Gaz. 1852, 414.
- On a new method of testing indigo : by *R. Lindenlaub*. J. pr. Chem. lii, 103 ; J. Pharm. [3] xxi, 231 ; Chem. Gaz. 1852, 149.
- On the valuation of indigo : by *F. Penny*. Chem. Soc. Qu. J. v, 297.
- Ink.**—On the manufacture of writing-inks. Pharm. J. Trans. xii, 65, 133.
- Inosite.**—On inosite : by *J. Scherer*. Ann. Ch. Pharm. lxxxi, 375 ; J. pr. Chem. liv, 705 ; Chem. Gaz. 1852, 167.
- Iodides.**—On a curious form of crystallization of iodide of potassium : by *R. Warington*. Chem. Soc. Qu. J. v, 136.
- On the iodide of starch, its decolouration by heat and by vegetable charcoal, and on the action of iodine on charcoal and wood-shavings : by *M. Lahens*. J. Pharm. [3] xxi, 13.
- On soluble iodide of starch and syrup of iodide of starch : by *M. Soubeiran*. J. Pharm. [3] xxi, 329.
- On soluble iodide of starch and the mode of preparing it : by *M. Seput*. J. Pharm. [3] xxi, 202.
- On the composition of iodide of nitrogen : by *R. Bunsen*. Ann. Ch. Pharm. lxxxiv, 1.
- Iodine.**—On the estimation of iodine : by *F. Penny*. Chem. Gaz. 1852, 309.
- On the presence of iodine in various plants, with some remarks on its general distribution : by *S. Macadam*. Proc. Bot. Soc. Edinb. July 8, 1852 ; Chem. Gaz. 1852, 281.
- On the qualitative and quantitative analysis of iodine, and its separation from bromine and chlorine by means of benzin and nitrate of silver : by *E. Moride*. Compt. rend. xxxv, 789.

- Iodine.—Comparative research of iodine and certain other matters in the waters which supply Paris, London and Turin : by *A. Chatin*. *Compt. rend.* xxxiv, 14 ; xxxv, 46, 127.
- Presence of iodine in the air, waters, soil and alimentary products of the Alps of France and of Piedmont : by *A. Chatin*. *Compt. rend.* xxxiv, 51.
- Report on memoirs relating to the detection of iodine, by *M. Chatin*, and on different notes and memoirs on the same subject, presented to the "Académie," by *MM. Marchand, Niepcé and Meyrac* : by *M. Bussy*. *Compt. rend.* xxxv, 505.—Observations on this report : by *M. Thénard*. *Ibid.* 516.
- Report on various processes for the detection of iodine : by *MM. Chatin and Gaultier de Claubry*. *J. Pharm.* [3] xxii, 194.
- Method of separating bromine and iodine, and of determining their ratio when mixed : by *O. Henry*. *J. Pharm.* [3] xxi, 255.
- Observations on the presence of iodine and bromine in aliments and secretions : by *M. Grange*. *Compt. rend.* xxxiv, 332.
- On the polarizing crystals produced by the action of iodine on sulphate of quinine : by *Dr. Herapath*. *Phil. Mag.* [4] iii, 161 ; iv, 186 ; *Chem. Soc. Qu. J.* v, 177.
- On the action of iodine upon phosphorus : by *B. C. Brodie*. *Chem. Soc. Qu. J.* v, 289.
- Iodoform.—Report on the process of *MM. Cornelis and Gille* for the preparation of iodoform : by *M. Poulenc*. *J. Pharm.* [3] xxii, 196, 361.
- Ipecacuanha.—Observations on ipecacuanha : by *M. Leroy*. *J. Pharm.* [3] xxi, 356.
- Iridium.—On a new salt of iridium : by *C. Karmrodt* and *E. Uhrlaub*. *Ann. Ch. Pharm.* lxxxi, 120.
- Iron.—Researches on the action exerted by salts of iron in the act of germination and vegetation, followed by a simple process for recognizing the small quantities of iron existing in the ashes of certain plants : by *J. L. Lassaigne*. *Compt. rend.* xxxiv, 587 ; *J. Pharm.* [3] xxii, 21.
- On a quick approximative method of estimating minute quantities of iron by means of a colorimeter : by *T. J. Herapath*. *Chem. Soc. Qu. J.* v, 27.
- Quantitative separation of sesquioxide of iron from the protoxide : by *T. Scheerer*. *Pogg. Ann.* lxxxvi, 91.
- Separation of the oxides of cerium from iron : by *C. Schmidt*. *Ann. Ch. Pharm.* lxxxiii, 325.
- On the commercial manufacture of sulphate of iron. *Pharm. J. Trans.* xi, 568.
- Researches on the influence of sulphur on the quality of cast-iron : by *M. Jauoyer*. *Ann. Min.* [4] xx, 359 ; *Chem. Gaz.* 1852, 227.
- Researches on the tempering of iron, (part 2) : by *M. Jullien*. *Compt. rend.* xxxiv, 913.
- Researches on iron. (Part 3.) Cementation of cast-iron by metallic oxides : by *M. Jullien*. *Compt. rend.* xxxv, 20.
- Analysis of meteoric iron : by *W. S. Clark*. *Ann. Ch. Pharm.* lxxxii, 367.
- Analysis of a specimen of meteoric iron. *Ann. Ch. Pharm.* lxxxii, 252.

- Iron.—Analysis of the meteoric iron of Rasgata: by *F. Wöhler*. Ann. Ch. Pharm. lxxxii, 243.
- Passive state of meteoric iron: by *F. Wöhler*. Ann. Ch. Pharm. lxxxii, 248; Pogg. Ann. lxxxv, 448.
- On the occurrence of metallic iron in fossil-wood: by *W. G. Lettsom*. Phil. Mag. [4] iv, 333; J. Pr. Chem. liv, 194; J. Pharm. [3] xxi, 233.
- Existence of iron in urine: by *G. Harley*. Pharm. J. Trans. xii, 243.
- On a new variety of magnetic iron ore: by *T. Andrews*. Chem. Gaz. 1852, 379.
- On the ferroso-ferric oxides and their compounds: by *J. Lefort*. Compt. rend. xxxiv, 488.
- Analysis of pig-iron and bog-iron ore (*Rasenerz*): by *H. L. Buff*. Ann. Ch. Pharm. lxxxiii, 376.
- On octohedral Oligist iron: by *T. S. Hunt*. Sill. Am. J. [2] xiii, 370.
- On the formation of iron pyrites in alluvial deposits of the present epoch: by *Malaguti* and *Durocher*. Compt. rend. xxxiv, 695.
- Analysis of magnetic iron pyrites containing nickel, from Gap mine, Lancaster County, Pennsylvania; by *M. H. Boye*. Sill. Am. J. [2] xiii, 219.
- Observations on nitride of iron: by *H. L. Buff*. Ann. Ch. Pharm. lxxxiii, 375.
- On the pyrophosphate of soda and iron: by *A. Ure*. J. Pharm. [3] xxi, 297.—Also by *L. Blyth*. Pharm. J. Trans. xi, 456.
- On the composition of a series of hydrated silicates of ferric oxide and potash: by *T. Scheerer*. Pogg. Ann. lxxxvii, 93.
- On sulphocyanide of ammonium as a test for iron-salts. J. Pharm. [3] xxi, 295; Pharm. J. Trans. xi, 296.
- Note on the use of sulphate of iron for the disinfection of manure, and on the solubility of the phosphates of iron: by *J. I. Pierre*. Ann. Ch. Phys. [3] xxxvi, 70; xxxiv, 546.
- Isinglass.—Process for obtaining liquid isinglass: by *S. Dumoulin*. Compt. rend. xxxv, 444.
- Isomerism.—On certain isomeric transformations of fats: by *Patrick Duffy*. Compt. rend. xxxv, 284; Chem. Soc. Qu. J. v, 197.
- Isomorphism.—Contributions to the more exact knowledge of polymeric isomorphism.—II. On the composition of a series of hydrated sulphates of ferric oxide and potash: by *T. Scheerer*. Pogg. Ann. lxxxvii, 72; further, lxxxiv, 321.
- On the chemical composition of the hydrocarbonates of magnesia, considered on the basis of polymeric isomorphism: by *T. Scheerer*. Pogg. Ann. lxxxv, 287.
- On the polymeric isomorphism of organic bodies: by *R. Wagner*. J. pr. Chem. liii, 449; Chem. Gaz. 1852, 1.
- Researches on the optical double refracting properties of isomorphous bodies: by *H. de Senarmont*. Ann. Ch. Phys. [3] xxxiii, 391.
- Ivory.—Protean stone or artificial ivory. Pharm. J. Trans. xii, 139.

J.

- Jalap.—On the resin of jalap and on perchlorinated succinic ether: by *A. Laurent*. *Compt. rend.* xxxv, 379.
 — On the resin of jalap: by *W. Mayer*. *Ann. Ch. Pharm.* lxxxiii, 121.

L.

- Lactucine.—On lactucine, lactucarium, and the *Cichoraceæ* of the genus *Lactuca*: by *E. Mouchon*. *J. Pharm.* [3] xxi, 454.
 Lamp.—Gas-lamp for laboratory use: by *A. W. Hofmann*. *Ann. Ch. Pharm.* lxxx, 226.
 Lamps.—Improvement in chemical lamps: by *W. Batka*. *Pogg. Ann.* lxxxv, 558.
 Laurostearone.—On myristone and laurostearone: by *A. Overbeck*. *Pogg. Ann.* lxxxvi, 591.
 Lead.—On the separation of metallic lead from the sulphate: by *C. Völckel*. *Ann. Ch. Pharm.* lxxxii, 64.
 — On the nitrite of lead: by *A. Gomès*. *Compt. rend.* xxxiv, 187.
 — Note on white-lead compared with zinc-white: by *M. Versepuy*. *Compt. rend.* xxxv, 103.
 — Facts relating to the theory of the preparation of white-lead: by *M. Barreswil*. *J. Pharm.* [3] xxii, 291.
 — On the occurrence of Diopside and molybdate of lead as crystalline furnace-products: by *J. F. L. Hausmann*. *Ann. Ch. Pharm.* lxxx, 219.
 — On Horn-lead and Matlockite, a new lead-ore from Derbyshire: by *C. Rammelsberg*. *Pogg. Ann.* lxxxv, 141.
 — Linarite (Bleilasur) from Nassau: by *F. Sandberger*. *Pogg. Ann.* lxxxv, 302.
 — On the organs in which lead accumulates in the horse, in cases of slow poisoning by that metal: by *G. Wilson*. *Proc. Roy. Soc. Edinb.* 1851-2, 119.
 — New mode of estimating lead by means of graduated solutions: by *H. Schwartz*. *Ann. Ch. Pharm.* lxxxiv, 84.
 Lemonade.—On the preparation of lemonade with citrate of magnesia: by *E. Robiquet*. *J. Pharm.* [3] xxi, 293.
 Light.—On the decomposition of the so-called nitroprusside of sodium by the solar rays: by *A. Overbeck*. *Pogg. Ann.* lxxxvii, 110.
 — On the influence of the solar radiations on the vital powers of plants: by *J. H. Gladstone*. *Chem. Gaz.* 1852, 377.
 — Results of some experiments on the chemical action of light: by *J. W. Slater*. *Chem. Gaz.* 1852, 325.
 — Researches on the optical double refracting powers of isomorphous bodies: by *H. de Senarmont*. *Ann. Ch. Phys.* [3] xxxiv, 391.
 Lime.—On the compounds of carbonic acid and water with lime: by *H. Rose*. *Pogg. Ann.* lxxxvi, 561.
 — On the existence of organic matter in stalactites and stalagmites, forming crystallized and amorphous crenate of lime: by *D. A. Wells*. *Sill. Am. J.* [2] xiii, 11; *Phil. Mag.* [4] iv, 155; *Chem. Gaz.* 1852, 72.
 — On some modern calcareous rock-formations: by *J. D. Dana*. *Sill. Am. J.* [2] xiv, 410.

- Lime.**—On the manner in which plants assist in the deposition of carbonate of lime : by *R. Ludwig* and *G. Theobald*. Pogg. Ann. lxxxvii, 91, 143.
- On phosphate of lime, considered with relation to the nutrition of animals and the mortality of children : by *M. Mourès*. Compt. rend. xxxv, 141.
- Action of hypochlorite of lime on oil of turpentine and other essential oils : by *M. Chautard*. J. Pharm. [3] xxi, 88.
- On the amount of water contained in the tribasic phosphate of lime : by *H. Ludwig*. Chem. Gaz. 1852, 367.
- Artificial formation of crystallized tungstate of lime : by *N. S. Manross*. Ann. Ch. Pharm. lxxxi, 243.
- Limulus.**—On the existence of copper in the blood of the *Limulus* : by *F. A. Genth*. Chem. Gaz. 1852, 109.
- Liquids.**—Additional observations on the diffusion of liquids : by *T. Graham*. Phil. Trans. 1851, ii, 483.
- New developments relating to the chemical effects produced by the contact of solids and liquids : by *M. Becquerel*. Compt. rend. xxxiv, 573.
- Lithia.**—On Petalite and Spodumene : by *C. Rammelsberg*. Pogg. Ann. lxxxv, 544.
- Lithography.**—Lithographic ink : by *M. Weishaupt*. Chem. Gaz. 1852, 416.
- Litmus.**—On litmus : by *J. Müller*. Pharm. J. Trans. xii, 255.
- Lungs.**—On a peculiar acid developed in the parenchyma of the lungs : by *F. Verdeil*. Ann. Ch. Pharm. lxxxi, 334.
- Lustre.**—Process for giving objects a pearly lustre : by *O. Reinsch*. Chem. Gaz. 1852, 235.
- Lycopodium.**—On the inorganic constituents of *Lycopodium Chamæcyparissus* and *L. clavatum*, with particular reference to the alumina which they contain : by *A. Aderholdt*. Ann. Ch. Pharm. lxxxii, 111.

M.

- Madder.**—Researches on madder : by *F. Rochleder*. Ann. Ch. Phys. [3] xxxv, 373 ; J. pr. Chem. lvi, 85 ; J. Pharm. [3] xxii, 69.
- Examination of the leaves of *Rubia tinctorum* : by *F. Rochleder*. Ann. Ch. Pharm. lxxxii, 205 ; Chem. Gaz. 1852, 21.
- Examination of the leaves of *Rubia tinctorum* : by *E. Willigk*. Ann. Ch. Pharm. lxxxii, 339 ; Chem. Gaz. 1852, 278.
- Improvements in extracting the colouring principles of madder. (Julian's patent. Chem. Gaz. 1852, 160.
- Preparation of madder and munjeet (C. Kurtz's patent). Chem. Gaz. 1852, 459 ; Pharm. J. Trans. xii, 304.
- On the compounds of madder : by *A. Laurent*. Ann. Ch. Phys. [3] xxxvi, 320.
- Magnesia.**—Indirect method of determining magnesia and the alkalies when they occur together : by *K. List*. Ann. Ch. Pharm. lxxxi, 117.
- On the chemical composition of the hydrocarbonates of magnesia, considered on the basis of polymeric isomorphism : by *Th. Scheerer*. Pogg. Ann. lxxxv, 287.

- Magnesia.**—Magnesia as an antidote to salts of copper: by *M. Roncha*. 1852, 133.
- Magnesium.**—Preparation of magnesium by the electrolytic method: by *R. Bunseu*. *Ann. Ch. Pharm.* lxxxii, 137; *Ann. Ch. Phys.* [3] xxxvi, 107.
- Manganese.**—On the distribution of manganese: by *D. A. Wells*. *Sill. Am. J.* [2] xiii, 1.
- Examination of manganese and chloride of lime, with regard to the amounts of peroxide of manganese and active chlorine which they contain: by *L. Müller*. *Ann. Ch. Pharm.* lxxx, 98; *Chem. Gaz.* 1852, 75.
- On the chemical constitution of the hydrocarbonates of manganese: by *T. Scheerer*. *Pogg. Ann.* lxxxvii, 87.
- Detection of manganese in limestone rocks: by *E. J. Chapman*. *Phil. Mag.* [4] iii, 144.
- Mannite.**—Reproduction of mannite and quercite from nitromannite and nitroquercite: by *V. Dessaignes*. *Ann. Ch. Pharm.* lxxxi, 251.
- Transformation of mannite into sugar: by *M. L'Hermite*. *Compt. rend.* xxxiv, 114.
- Manometer.**—Description of a metallic manometer, and other instruments for measuring pressures and temperatures: by *E. Bourdon*. *J. Frank. Inst.* [3] xxiii, 102.
- Manure.**—Results of experiments on the use of ammonio-magnesian phosphate as a manure: by *J. I. Pierre*. *Ann. Ch. Phys.* [3] xxxvi, 47; *Compt. rend.* xxxiv, 189.
- On the use of sulphate of iron for the disinfection of manure, and on the solubility of the phosphates of iron: by *J. I. Pierre*. *Compt. rend.* xxxiv, 546; *Ann. Ch. Phys.* [3] xxxv, 70.
- Note on the danger of transforming the carbonate of ammonia contained in manure into fixed salts: by *M. Jacquenart*. *Compt. rend.* xxxv, 725.
- Matches.**—Improved chemical compositions for making gun-matches. *Pharm. J. Trans.* xii, 143.
- Menispermum.**—On the occurrence of berberine in the Columbo wood of Ceylon (*Menispermum* [*Coscinium*] *fenestratum*): by *J. D. Perrins*. *Ann. Ch. Pharm.* lxxxiii, 276; *Phil. Mag.* [4] iv, 99; *Pharm. J. Trans.* xii, 189.
- Mercury.**—On a new compound of mercury: by *Sobrero* and *Selmi*. *Ann. Ch. Pharm.* lxxx, 108; *Chem. Soc. Qu. J.* 86.
- On the new mercury-compound of Sobrero and Selmi: by *Werther* and *Brückner*. *J. pr. Chem.* lv, 253; *Chem. Gaz.* 1852, 251.—Also by *W. Knop*. *Pharm. Centrbl.* xxiii, 431; *Chem. Gaz.* 1852, 313.
- On ethylmercuric nitrate: by *C. Gerhardt*. *Ann. Ch. Pharm.* lxxx, 111; *Chem. Soc. Qu. J.* v, 88.
- New test for mercury: by *A. Morgan*. *J. Pharm.* [3] xxi, 299; *Pharm. J. Trans.* xi, 372; *Chem. Gaz.* 1852, 158.
- On certain double-salts of cyanide of mercury: by *G. Kohl* and *A. Svoboda*. *Ann. Ch. Pharm.* lxxxiii, 339.
- On the double-salt of chromate of potash with cyanide of mercury: by *C. Rammelsberg*. *Pogg. Ann.* lxxxv, 145.

- Mercury.**—On several new sulphites of mercuric oxide: by *L. Péan de Saint-Gilles*. Ann. Ch. Phys. [3] xxxvi, 80; Compt. rend. xxxiv, 945.
- Composition of antimoniate of mercury from the silver mines near Coquimbo: by *M. Domeyko*. Compt. rend. xxxv, 50.
- Note on a new acid extracted from the mother-liquor of fulminate of mercury: by *S. Cloez*. Compt. rend. xxxiv, 364.
- On the indirect bleaching powers of mercury and stibethyl: by *C. F. Schönbein*. J. pr. Chem. lvi, 353; Phil. Mag. [4] iv, 238.
- Contribution to the chemical history of the mercury-compounds of the alkaloids: by *Fr. Hinterberger*. Ann. Ch. Pharm. lxxxii, 311; Chem. Gaz. 1852, 422, 444.
- On the analysis of unguents containing oxygenated compounds of mercury: by *M. Mayet*. J. Pharm. [3] xxii, 119.
- Metalbumin.**—On paralbumin and metalbumin: by *J. Scherer*. Ann. Ch. Pharm. lxxxii, 135.
- Metals.**—On the elasticity of metals: by *A. W. Napiersky*. Pogg. Ann. Ergänzungs-band iii, 357.
- On the reduction of metals by phosphorus and sulphur: by *W. Wicke*. Ann. Ch. Pharm. lxxxii, 145; Chem. Gaz. 1852, 348.
- On the permeability of metals to mercury: by *Prof. Horsford*. Sill. Am. J. [2] xiii, 305.
- Improvements in the manufacture of copper, and in the separation of some other metals therefrom, and in the production of the alloys of certain metals: by *A. Parkes*. Chem. Gaz. 1852, 218.
- Improvements in obtaining metals and metallic products from the residues of certain processes (Richardson's patent). Pharm. J. Trans. xii, 305.
- On the conductivity of metals for heat: by *H. J. Gouillard*. Compt. rend. xxxv, 699.
- Metaphosphates.**—Action of water at a high temperature and under strong pressure on the metaphosphates: by *A. Reynoso*. Compt. rend. xxxiv, 795.
- Meteorite.**—Analysis of meteoric iron: by *W. S. Clark*. Ann. Ch. Pharm. lxxxii, 367.
- Analysis of the meteoric iron of Rasgata: by *F. Wöhler*. Ann. Ch. Pharm. lxxxii, 243.
- Passive state of meteoric iron: by *F. Wöhler*. Pogg. Ann. lxxxii, 448.
- The meteorite of Lixna: by *Eichwald*. Pogg. Ann. lxxxv, 574.
- Methyl.**—On the preparation of pure methylic alcohol. Ann. Ch. Pharm. lxxxi, 375.
- On Stibmethylum and its compounds: by *H. S. Landolt*. Ann. Ch. lxxxiv, 44. Chem. Gaz. 1852, 381, 484.
- Milk.**—Description of a *monstre pygomèle* of the bovine race, followed by a chemical analysis of the milk yielded by each of the component individuals: by *N Joly* and *E. Filhol*. Compt. rend. xxxiv, 640; Ann. Ch. Phys. [3] xxxvi, 355.
- Mineral Analyses.**—(Apatite, Augite, Arsenical Nickel, Dolerite, Garnet, Silicate of copper, Schorlamite): by *C. Rammelsberg*. Pogg. Ann. lxxxv, 297.

- Mineral Analyses.**—Quartziferous Red Porphyry, Melapyses, Blue Porphyry, Trachyte: by *M. Diday*. Ann. Min. [5] ii, 181.
- Mineralogical Notices.**—On Crednerite, Helvine, false cleavage in Garnet; also on Phenacite and Beryl, Sphene and Epidote, Chlorite Spar and Chloritoid, Wichtyne, minerals of the Epidote type, Chrome Tourmalines, detection of Manganese in limestone rocks, Barytine: by *E. J. Chapman*. Phil. Mag. [4] iii, 144.
- On Galena, Fahlerz, Feather-ore (Heteromorphite), Boulangerite, Jamesonite, Meneghinite, Copper-glance (Chalkosine), Chalcopyrite, Erubescite, Zigueline, White Antimony, Marmitite, Oxide of Zinc, Braunite, Chrome-iron, Silicated Chrome (Wolchonskoite?), Caporicianite, Picranalcime, Picrothomsonite, Portite, Sloanite, Schneiderite, Savite, Humboldtite (Datolite): by *Prof. Meneghini*. Sill. Am. J. [2] xiv, 60.
- On Chlorite, Red Sapphire, Argentiferous Galena, Chalcotrichite, Sulphide of Nickel, and Lievrite: by *N. P. Blake*. Sill. Am. J. [2] xiii, 117.
- Minerals.**—Examination of some American minerals—Columbite, Samarskite, Rutherfordite: by *T. S. Hunt*. Sill. Am. J. [2] xiv, 340.
- Chemical examination of certain minerals: by *C. Bergemann*. Pogg. Ann. lxxxiv, 485.
- Analysis of some Scottish minerals: by *A. J. Scott*. Proc. Roy. Soc. Edinb. 1851-2, 122.
- Description of two new minerals (*Thalite*, and a Kettle River mineral resembling *Saponite*) and a new earth (*Thalia*): by *D. Owen*. Sill. Am. J. [2] xiii, 420; Chem. Gaz. 1852, 341.
- Chemico-mineralogical contributions: by *E. E. Schmid*. Pogg. Ann. lxxxiv, 495.
- On the artificial formation of several mineral compounds: by *M. Bequerel*. Compt. rend. xxxiv, 29.
- Experiments on the artificial production of crystallized minerals: by *N. S. Manross*. Ann. Ch. Pharm. lxxxii, 348.
- Apatite.**—On the chemical composition of the Apatite of Snarum: by *G. Rose*. Pogg. Ann. lxxxiv, 303.—Also by *R. Weber*. Ibid. 306.
- Asbestos.**—Examination of the so-called Iron-asbestos: by *C. Schnabel*. Pogg. lxxxv, 462.
- Basalt.**—On the composition and microscopic structure of certain basaltic and metamorphic rocks: by *T. Andrews*. Chem. Gaz. 1852, 416.
- Bergmannite.**—On Giesseckite and Bergmannite (*Spreustein*), two metamorphic pseudomorphoses of Nepheline: by *R. Blum*. Pogg. Ann. lxxxvii, 315.
- Carrollite.**—On Carrollite, a new cobalt mineral: by *W. L. Faber*. Sill. Am. J. [2] xiii, 418.
- Catapleiite.**—Chemical examination of Catapleiite, a new mineral from Lamö in Norway: by *K. A. Sjögren*. Pogg. Ann. Ergänzungs-band iii, 465.
- Childrenite.**—On Childrenite: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 435; Phil. Mag. [4] iv, 118.

- Minerals: Chlorite.**—On crystals of Chlorite from the Achmatow Mine in the Ural, and their relation to the Chlorite from Schwarzenstein in the Tyrol, to the Ripidolite of St. Gothard and other localities, to Laphorite, Pennin and Kämmererite (Rhadochrome): by *N. v. Kokscharow*. Pogg. Ann. lxxxv, 519.
- Clinochlore.**—On the Clinochlore of Chester County, Pennsylvania: by *W. J. Crawford*. Sill. Am. J. [2] xiii, 222.
- Dimagnetite**—On Dimagnetite, a new mineral from Monroe, Orange County: by *C. U. Shephard*. Sill. Am. J. [2] xiii, 392.
- Diopside.**—On the occurrence of Diopside and Molybdate of lead as crystalline furnace-products: by *J. Fr. L. Hausmann*. Ann. Ch. Pharm. lxxxi, 219.
- Epidote.**—Remarks on the composition of Epidote: by *C. Rammelsberg*. Pogg. Ann. lxxxiv, 453.
- Eumanite.**—On the angles of Eumanite: by *J. E. Teschemacher*. Sill. Am. J. [2] xiii, 117.
- Francolite.**—On Francolite, a supposed new mineral: by *T. H. Henry*. Pogg. Ann. lxxxiv, 311.
- Gieseckite.**—*Vide* Bergmannite.
- Glauberite.**—Note on the forms of the Glauberite of Iquique (Peru): by *H. de Senarmont*. Ann. Ch. Phys. [3] xxxvi, 155.
- Granite.**—On the alterations of Granite Rocks: by *M. Delesse*. Compt. rend. xxxv, 195.
- Horn-lead.**—On Horn-lead and Matlockite, a new lead-ore from Derbyshire: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 141.
- Humite.**—On the crystallographical and chemical relations of Humite (Chondrodite) and Olivine: by *C. Rammelsberg*. Pogg. Ann. lxxxvi, 404.
- On the Humite of Monte Somma: by *A. Sacchi*. Pogg. Ann. Ergänzung, iii, 161.—Abstract, with observations: by *J. D. Dana*. Sill. Am. J. [2] xiv, 175.
- Jenkinsite.**—On Jenkinsite, a new mineral from Monroe, Orange County: by *C. U. Shephard*. Sill. Am. J. [2] xiii, 392.
- Lithomarge.**—Analysis of Lithomarge from the Saxon Topaz rock. Ann. Ch. Pharm. lxxx, 122.
- Marekanite.**—On the supposed electrical conducting power of Marekanite: by *W. Hankel*. Pogg. Ann. lxxxvii, 67.
- Matlockite.**—On Horn-lead and Matlockite, a new lead-ore from Derbyshire: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 141.
- Mica.**—Observations on the optical properties and crystalline forms of certain Micas: by *H. de Senarmont*. Ann. Ch. Phys. [3] xxxiv, 171; Compt. rend. xxxiii, 684.
- On a new macle formation of Mica: by *Dr. Ettling*. Ann. Ch. Pharm. lxxxii, 337.
- Oligist.**—On octohedral Oligist Iron: by *T. S. Hunt*. Sill. Am. J. [2] xiii, 370.
- Olivine.**—On the crystallographical and chemical relations of Humite (Chondrodite) and Olivine: by *C. Rammelsberg*. Pogg. Ann. lxxxvi, 404.

- Minerals: Orangite.—Chemical researches on a new oxide obtained from a Norwegian mineral: examination and analysis of Orangite: by *A. Damour*. Compt. rend. xxxiv, 685.
- Petalite.—On Petalite and Spodumene: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 544.
- Phenakite.—On a new locality of Phenakite: by *Prof. Miller*. Phil. Mag. [4] iii, 378.
- Pigolite.—Analysis of a substance resembling the Pigolite of Prof. Johnston: by *Prof. Apjohn*. Chem. Gaz. 1852, 378.
- Placodine.—On Placodine: by *J. Plattner*. Pogg. Ann. lxxxii, 461.
- On Nickel-speiss and Placodine: by *G. Rose*. Pogg. Ann. lxxxiv, 585.
- Pumice.—Notice regarding the origin of Pumice in the island of Tyree: by the *Duke of Argyll*. Proc. Roy. Soc. Edinb. 1851-2, 120.
- Pyrites.—Analysis of Magnetic Iron-pyrites containing nickel, from Gap mine, Lancaster County, Pennsylvania: by *M. H. Boye*. Sill. Am. J. [2] xiii, 219.
- Remingtonite.—On Remingtonite, a new cobalt mineral: by *J. C. Booth*. Sill. Am. J. [2] xiv, 48.
- Serpentine.—Chemical examination of a few minerals associated with Serpentine: by *T. H. Garrett*. Sill. Am. J. [2] xiv, 45.
- Slate.—Chemico-mineralogical examination of the Taunus Slate: by *K. List*. Ann. Ch. Pharm. lxxxi, 181.
- Sommite.—On Sommite (Nepheline), Mizzonite, and Mejonite: by *A. Sacchi*. Pogg. Ann. Ergänzungs-band iii, 478.
- Spodumene.—On Petalite and Spodumene: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 544.
- Stalactites.—On the existence of organic matter in Stalactites and Stalagmites, forming crystallized and amorphous crenate of lime: by *D. A. Wells*. Sill. Am. J. [2] xiii, 11.
- Triphylin.—On the Triphylin of Bodenmais: by *C. Rammelsberg*. Pogg. Ann. lxxxv, 435.
- Molecular Action.—Researches on the quantities of heat disengaged in chemical and molecular actions: by *P. A. Favre* and *J. T. Silbermann*. Ann. Ch. Phys. [3] xxxiv, 385; xxxvi, 5.
- Molybdenum.—On the preparation of pure molybdenum-compounds from native molybdate of lead: by *L. A. Buchner*. Ann. Ch. Pharm. lxxxiii, 320.
- Process for obtaining molybdic acid from molybdate of lead: by *Chr. Elbers*. Ann. Ch. Pharm. lxxxiii, 215.
- New process for obtaining molybdate of ammonia: by *W. Delffs*. Pogg. Ann. lxxxv, 450.
- On neutral molybdate of ammonia: by *F. A. Flickiger*. Pogg. Ann. lxxxvi, 594.
- On the determination of phosphoric acid by molybdate of ammonia: by *W. J. Craw*. Sill. Am. J. [2] xiii, 393; Chem. Gaz. 1852, 6.
- On some molybdates, and the application of molybdic acid to the determination of phosphoric acid: by *M. Sonnenschein*. J. pr. Chem. liii, 339 Chem. Gaz. 1852, 388.

- Molybdenum.**—On the occurrence of Diopside and Molybdate of lead as crystalline furnace-products: by *J. Fr. L. Hausmann*. Ann. Ch. Pharm. lxxxi, 219.
- Mountain-ash.**—On a new kind of sugar obtained from the berries of the mountain-ash: by *J. Pelouze*. Ann. Ch. Phys. [3] xxxv, 223; Ann. Ch. Pharm. lxxxiii, 47; J. Pharm. [3] xxi, 321; Compt. rend. xxxiv, 377; Chem. Soc. Qu. J. v, 281.
- Mucilage.**—On vegetable mucilage and substances allied thereto; by *Dr. Kützing*. Arch. Pharm. [2] lxvii, 1; Pharm. J. Trans. xi, 327.
- Mummy.**—Chemical and microscopical examination of the fabrics surrounding an Egyptian mummy, with some remarks on the analysis of the flesh of the mummy, and on the Egyptian method of embalming: by *W. and T. J. Herapath*. Chem. Gaz. 1852, 362.
- Myristone.**—On myristone and laurostearone: by *A. Overbeck*. Pogg. Ann. lxxxvi, 591.

N.

- Narcotine.**—Observations on narcotine: by *M. Wertheim*. J. pr. Chem. liii, 431; Chem. Gaz. 1852, 37.
- Narwhal.**—Analysis of the tooth of the narwhal: by *C. A. Joy*. Ann. Ch. Pharm. lxxxii, 365.
- Nickel.**—Analysis of magnetic iron-pyrites containing nickel, from Gap mine, Lancaster County, Pennsylvania: by *M. H. Boye*. Sill. Am. J. [2] xiii, 219.
- On the combinations of carbonic acid and water with the oxides of nickel and cobalt: by *H. Rose*. Chem. Gaz. 1852, 132.
- On a compound of sulphur, nickel and bismuth: by *G. Werther*. J. pr. Chem. lv, 227; Chem. Gaz. 1852, 253.
- On Nickel-speiss and Placodine: by *G. Rose*. Pogg. Ann. lxxxiv, 585.
- On the separation of nickel and cobalt: by *J. D. Smith*. Chem. Gaz. 1852, 259.
- On the detection of nickel and cobalt in the mineral waters of Nérac: by *M. Mazade*. Compt. rend. xxxiv, 479.
- Nicotine.**—On the proportion of nicotine contained in the tobacco of Paraguay, and on the extraction of that alkaloid: by *M. Lenoble*. J. Pharm. [3] xxii, 30.
- On poisoning by nicotine: by *M. Orfila*. Chem. Gaz. 1852, 187.
- Nitrates.**—Improvements in the manufacture of nitrates, and of hydrate and carbonate of soda. Pharm. J. Trans. xii, 141.
- On ethylmercuric nitrate: by *C. Gerhardt*. Ann. Ch. Pharm. lxxx, 111; Chem. Soc. Qu. J. v, 88.
- Manufacture of nitrate of potash. Pharm. J. Trans. xii, 30.
- On the origin of nitre: by *M. Desmarest*. Compt. rend. xxxiv, 984.
- Nitrides.**—Observations on nitride of iron: by *H. L. Buff*. Ann. Ch. Pharm. lxxxiii, 375.
- Nitrification.**—On the oxidation of ammonia in the human body, with some remarks on nitrification: by *H. Bence Jones*. Phil. Trans. 1851, ii, 399; Ann. Ch. Phys. [3] xxxv, 176.
- Nitrites.**—On the nitrite of lead: by *A. Goniès*. Compt. rend. xxxiv, 187.

- Nitrogen.**—New method for the quantitative determination of nitrogen in organic substances by measuring its volume: by *W. Heintz*. Pogg. Ann. lxxxv, 263; Chem. Gaz. 1852, 139.
- On a modification of the process for the determination of nitrogen in organic compounds: by *A. Kemp*. Proc. Roy. Soc. Edinb. 1851-2, 126.
- On the determination of nitrogen: by *M. Ullgren*. J. pr. Chem. lv, 21; Chem. Gaz. 1852, 300.
- On the behaviour of the nitrogenous compounds of sugar with reducing agents: by *A. and W. Knop*. Pharm. Centrbl. xxiii, 423; Chem. Gaz. 1852, 295.
- On the composition of iodide of nitrogen: by *R. Bunsen*. Ann. Ch. Pharm. lxxxiv, 1.
- Nitroprussides.**—Preparation of nitroprusside of sodium: by *E. Roussin*. Pharm. J. Trans. xii, 44.
- Contribution to the chemical history of nitroprusside of sodium: by *C. Rammelsberg*. Pogg. Ann. lxxxvii, 107.
- On the decomposition of the so-called nitroprusside of sodium by the solar rays: by *A. Overbeck*. Pogg. Ann. lxxxvii, 110.
- Nutrition.**—Researches on respiration and nutrition: by *M. Clement*. Compt. rend. xxxiv, 977.
- Experiments undertaken to determine the relative nutritious qualities of the most ordinary kinds of meat: by *M. Marchal*. Compt. rend. xxxiv, 591.
- On phosphate of lime, considered with relation to the nutrition of animals and the mortality of children: by *M. Mourès*. Compt. rend. xxxv, 141.

O.

- Oats.**—Researches on the nutrition of oats, particularly as regards the inorganic matters required: by the *Prince of Salm-Horstmar*. Ann. Ch. Phys. [3] xxxv, 54.
- Oils.**—Analysis of oils by means of sulphuric acid: by *M. Maumené*. Compt. rend. xxxv, 572.
- Researches on vegetable fatty oils: by *J. Lefort*. Compt. rend. xxxv, 734.
- On the compounds of certain essential oils with the alkaline bisulphites: by *C. Bertagnini*. Compt. rend. xxxv, 800; Chem. Soc. Qu. J. v, 317.
- On the action of essential oil of mustard on organic bases: by *N. Linin*. Chem. Gaz. 1852, 441.
- Researches on oil of beet-root: by *M. A. Müller*. J. pr. Chem. lvi, 103; J. Pharm. [3] xxii, 160.
- On the mode of ascertaining the purity of essential oil of bitter almonds: by *J. Ferris*. Pharm. J. Trans. xi, 565; also by *T. Redwood*. Pharm. J. Trans. xi, 486; J. Pharm. [3] xxii, 116.
- On oil of cloves: by *G. von Heet*. Pharm. J. Trans. xi, 470.
- On the distillation of volatile oil of cloves by means of superheated steam: by *M. Scharling*. J. Pharm. [3] xxvi, 295; Pharm. J. Trans. xi, 469.
- On the so-called Hungarian oil of wine: by *H. Schwartz*. Ann. Ch. Pharm. lxxxiv, 82.

- Oils—Researches on the chemical composition of cod-liver oil : by *F. L. Winkler*. N. Rept. Pharm. i, 65 ; J. Pharm. [3] xxii, 225 : Chem. Gaz. 1852, 368 ; Pharm. J. Trans. xii, 36.
- Chemical examination of cod-liver oil : by *M. Riegel*. Arch. Pharm. [2] lxx, 17 ; J. Pharm. [3] xxii, 79.
- On the proportions of iodine contained in cod-liver oils : by *Chevallier* and *Gobley*. Pharm. J. Trans. xi, 321.
- On the substitution of an artificial ioduretted oil for cod-liver oil : Pharm. J. Trans. xi, 318.
- On drying linseed oil obtained without heat : by *J. Liebig*. J. Pharm. [3] xxii, 47 ; Pharm. J. Trans. xi, 47.
- On the action of Wurtz's bases upon oil of mustard : by *Fr. Hinterberger*. Ann. Ch. Pharm. lxxxiii, 346.
- On oil of geranium having the odour of roses. Pharm. J. Trans. xi, 325.
- Note on the oil of the *Squalus maximus* : by *E. Ronalds*. Chem. Gaz. 1852, 420.
- Action of hypochlorite of lime on oil of turpentine and other essential oils : by *M. Chantard*. J. Pharm. [3] xxi, 88.
- Action of acids, heat, and the chlorides of the alkali- and earth-metals on oil of turpentine and hydrate of turpentine : by *M. Berthelot*. Ann. Ch. Pharm. lxxxiii, 104.
- On a new compound of oil of turpentine : by *A. Sobrero*. Ann. Ch. Pharm. lxxx, 106.
- Opine.—On porphyroxine or opine : by *M. Roberston*. J. Pharm. [3] xxii, 190.
- Opium.—Researches on some of the crystalline compounds of opium : by *T. Anderson*. Ed. Phil. Trans. xx, Pt. 3, 347 ; *abstr.* Proc. Roy. Soc. Edinb. 1851-2, 132 ; Chem. Soc. Qu. J. v, 257.
- On the analysis of opium, especially with reference to the amount of morphia contained therein : by *Dr. Riegel*. Pharm. J. Trans. xi, 418.
- Organic Bases.—Researches into the molecular constitution of the organic bases : by *A. W. Hofmann*. (Second memoir.) Phil. Trans. 1851, ii, 357.
- On a general method for the discovery of organic alkalies in cases of poisoning : by *M. Stas*. J. Pharm. [3] xxii, 281 ; Chem. Gaz. 1852, 348 ; Pharm. J. Trans. xii, 195.
- Organic bases containing antimony. Chem. Soc. Qu. J. v, 66.
- Formation of the ethyl-bases by means of chloride of ammonium : by *M. Berthelot*. Compt. rend. xxxiv, 802 ; Ann. Ch. Pharm. lxxxiii, 109.
- On the action of Wurtz's bases on oil of mustard : by *Fr. Hinterberger*. Ann. Ch. Pharm. lxxxiii, 346.
- Researches on the compounds of sulphuric acid with organic substances : by *Gerhardt* and *Chancel*. Compt. rend. xxxv, 690.
- Organic Radicals.—Researches on the oxygenated radicals : by *L. Chiozza*. Compt. rend. xxxv, 225 ; Ann. Ch. Pharm. lxxxiv, 102.
- Organic Substances.—On the quantitative determination of sulphur in organic substances : by *W. Heintz*. Pogg. Ann. lxxxv, 424.

- Organic Substances.—New process for separating arsenic from organic substances: by *Schneider*. Pogg. Ann. lxxxv, 433.
- Researches on two new organic compounds: by *A. Lamy*. Ann. Ch. Phys. [3] lxxxv, 514.
- Oxalates.—On the acid oxalates of the earths: by *E. Clapton*. Chem. Soc. Qu. J. v, 223.
- Oxamide.—Formation of oxalic ether and oxamide in the distillation of aldehyde-ammonia: by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 330.
- Oxygen.—Researches on the means of extracting, for technical purposes, the oxygen contained in atmospheric air: by *M. Boussingault*. Ann. Ch. Phys. [3] xxxv, 5; Chem. Soc. Qu. J. v, 269.
- On the electro-chemical function of oxygen: by *M. Viard*. Ann. Ch. Phys. [3] xxxvi, 129.
- On the form in which the absorbed oxygen is contained in the blood: by *J. Liebig*. J. Pharm. [3] xxi, 337.
- On a mode of separating, in the pure state, from melting silver, the oxygen which it has absorbed from the air: by *M. Levol*. Compt. rend. xxxv, 63.
- Oxysulphocarbonates.—On the action of ammonia on binoxysulphocarbonate of amyl: by *M. W. Johnson*. Chem. Soc. Qu. J. v, 142.
- Ozone.—On the nature and name of ozone: by *C. F. Schönbein*. Phil. Mag. [4] iv, 542.
- On the quantitative determination of ozone: by *C. F. Schönbein*. Phil. Mag. [4] iv, 545.

P.

- Paper.—Improvements in the chemical treatment of the raw materials used in the manufacture of paper, and in obtaining oxalic acid. Pharm. J. Trans. xii, 258.
- Paper for bankers' cheques. Pharm. J. Trans. xii, 140.
- Paralbumin.—On paralbumin and metalbumin: by *J. Scherer*. Ann. Ch. Pharm. lxxxii, 135; J. pr. Chem. liv, 402; J. Pharm. [3] xxi, 474.
- Parenchyma.—On a peculiar acid secreted by the pulmonary parenchyma: by *F. Verdeil*. Chem. Gaz. 1852, 14.
- Paricine.—On paricine: by *F. L. Winckler*. J. Pharm. [3] xxi, 395.
- Pastilles.—On the alteration of pastilles: by *F. Huraut*. J. Pharm. [3] xxi, 112.
- Percarbonic Compounds.—On uric, chlorosulphalic and percarbonic compounds: by *A. Laurent*. Compt. rend. xxxv, 629.
- Perfumery.—Organic chemistry in its application to perfumery: by *A. W. Hofmann*. Ann. Ch. Pharm. lxxxii, 87.
- Perspiration.—Researches on the chemical composition of human perspiration: by *P. A. Favre*. Compt. rend. xxxv, 721.
- Phosphates.—On the triple or ammonio-magnesian phosphates occurring in the urine and other animal fluids: by *J. W. Griffith*. Phil. Mag. [4] iii, 373.

- Phosphates.—Results of experiments on the use of ammonio-magnesian phosphate as manure: by *J. I. Pierre*. Ann. Ch. Phys. [3] xxxvi, 47.
- Note on the use of sulphate of iron for the disinfection of manures, and on the solubility of the phosphates of iron: by *J. I. Pierre*. Ann. Ch. Phys. [3] xxxvi, 70.
- On phosphate of lime, considered in relation to the nutrition of animals and the mortality of children: by *M. Mourière*. Compt. rend. xxxv, 141.
- On the amount of water contained in tribasic phosphate of lime: by *H. Ludwig*. Chem. Gaz. 1852, 367.
- Action of water at a high temperature and under strong pressure on the pyrophosphates, metaphosphates, cyanides, &c.: by *A. Reynoso*. Compt. rend. xxxiv, 795; J. Pharm. [3] xxii, 14.
- On the pyrophosphate of soda and iron: by *A. Ure*. J. Pharm. [3] xxi, 297.
- On soda-pyrophosphate of iron: by *L. Blyth*. Pharm. J. Trans. xi, 456.
- Phosphorus.—Amorphous phosphorus. Pharm. J. Trans. xi, 369.
- On the equivalent of phosphorus: by *V. Jacquelin*. Compt. rend. xxxiii, 693.
- Observations on the preparation of phosphorus: by *M. Donovan*. J. Pharm. [3] xxi, 41; J. pr. Chem. lii, 103.
- On the action of iodine upon phosphorus: by *B. C. Brodie*. Chem. Soc. Qu. J. v, 289.
- On the separation of phosphorus from iron and alumina: by *A. Reynoso*. J. Pharm. [3] xxi, 28.
- Reduction of metals by phosphorus and sulphur: by *W. Wicke*. Ann. Ch. Pharm. lxxxii, 145.
- On the utricular form and the crystallization of phosphorus: by *M. Brame*. Compt. rend. xxxv, 728.
- On phosphide of tungsten: by *F. Wöhler*. Chem. Soc. Qu. J. v, 94.
- Photography.—Method of obtaining direct positive pictures upon glass: by *A. Martin*. Compt. rend. xxxv, 29.
- On the production of instantaneous photographic images: by *H. F. Talbot*. J. Frank. Inst. [3] xxiii, 137.
- Description of a new method of preparing negative photographic paper: by *G. Legray*. J. Frank. Inst. [2] xxiv, 65.
- On the collodion process in photography: by *F. S. Archer*. J. Frank. Inst. [3] xxiii, 205.
- Note on the use of collodion in photography: by *M. Bingham*. Compt. rend. xxxiv, 724.
- Photography on glass: J. Frank. Inst. [3] xxiii, 120.
- On the production of photographs on glass: by *J. Pucher*. Arch. Pharm. [2] lxi, 361; Chem. Gaz. 1852, 291.
- Gutta serena in photography. J. Frank. Inst. [3] xxiii, 206.
- Note on a photometric property of Daguerreotype plates: by *M. Pouillet*. Compt. rend. xxxv, 373.
- Note on the means of multiplying photographic pictures on metal, by transferring them to albuminized glass: by *A. Rochas*. Compt. rend. xxxiv, 250.
- Note on a method of procuring very rapid photographs: by *J. Stuart*. Proc. Roy. Soc. Edinb. 1851-2, 116.

- Photography.—Third memoir on heliography, by *Niepcé de St.-Victor*. *Compt. rend.* xxxv, 694.—Remarks on this communication: by *M. Becquerel*. *Ibid.* 697.
- Phycite.—On phycite, the saccharine matter of *Protococcus vulgaris*: by *A. Lamy*. *Ann. Ch. Phys.* [3] xxxv, 138.
- Physaline.—On physaline, the bitter principle of the winter-cherry (*Physalis alkekengi*): by *Dessaignes* and *Chantard*. *J. Pharm.* [3] xxi, 24.
- Piperine.—On a new alkali derived from piperine: by *A. Cahours*. *Compt. rend.* xxxiv, 481.
- Reclamation of priority relative to a recent note of *M. Cahours* on a volatile base obtained from piperine: by *T. Anderson*. *Compt. rend.* xxxiv, 564. Reply by *M. Cahours*. *Ibid.* 696.
- Placodine.—Breithaupt's Placodine probably a furnace-product: by *C. Schnabel*. *Pogg. Ann.* lxxxiv, 585.
- Plants.—Researches on the green colouring-matter of plants: by *F. Verdeil*. *Compt. rend.* xxxiii, 689.
- Influence of ammonia added to the air, on the development of plants: by *M. Ville*. *Compt. rend.* xxxv, 650.
- New researches on the respiration of plants: by *M. Garreau*. *Compt. rend.* xxxiv, 104.
- On the sources of fluorine in plants, with some new observations on the sources whence vegetables derive that element: by *G. Wilson*. *Proc. Bot. Soc. Edinb.* July 8, 1852; *Chem. Gaz.* 1852, 309.
- On the influence of the solar radiations on the vital powers of plants: by *J. H. Gladstone*. *Chem. Gaz.* 1852, 377.
- On the behaviour of the roots of various species of plants in saline solutions: by *J. Schlossberger*. *Ann. Ch. Pharm.* lxxxi, 172.
- On the manner in which plants assist in the deposition of carbonate of lime: by *R. Ludwig* and *G. Theobald*. *Pogg. Ann.* lxxxvii, 91, 143.
- Plastic Material.—On a new plastic material for forming various objects: by *Prof. Purkinje*. *Gewerbebl. aus Würtemb.* 1852, 45; *Chem. Gaz.* 1852, 259.
- Plating.—Facts relating to the history of galvanic plating: by *M. Bouillet*. *J. Pharm.* [3] xxi, 44.
- Platinum.—On the atomic weights of platinum and barium: by *T. Andrews*. *Chem. Gaz.* 1852, 37.
- Platinum in the Alps: by *M. Gueymard*. *Ann. Min.* [5] i, 345.
- On platinum-black: by *W. Knop*. *Pharm. Centrbl.* xxiii, 431; *Chem. Gaz.* 1852, 313.
- Observations on a new series of double chlorides containing diplatosis-ammonium: by *G. B. Buckton*. *Chem. Soc. Qu. J.* v, 213.
- Poisons.—On the elimination of certain poisons; comparison of various methods of detection; action of ethylamine and anylamine on the animal economy: by *A. F. Orfila*. *Compt. rend.* xxxiv, 97.
- Polarized Light.—Experiments to prove that substances possessed of rotatory power, when they are dissolved in inactive media having no chemical action upon them, enter with these media, into a state of transient combination, not in definite proportions, which affects their entire mass, and subsists as long as the mixed system remains fluid: by *M. Biot*. *Compt. rend.* xxxv, 233; *Ann. Ch. Phys.* [3] xxxvi, 257.

- Polarized Light.—New researches in the relations which may exist between crystalline form, chemical composition and rotatory power: by *A. Pasteur*. Compt. rend. xxxv, 176.
- On the polarizing crystals produced by the action of iodine on sulphate of quinine: by *Dr. Herapath*. Phil. Mag. [4] iii, 161; iv, 186; Chem. Soc. Qu. J. v, 177.
- On Soleil's polariscope for determining the quantity of sugar in a solution: by *H. Bence Jones*. Pharm. J. Trans. xi, 455.
- On the relation of certain crystals to polarized light: by the *Prince of Salm-Horstmar*. Pogg. Ann. lxxxiv, 515.
- On the detection of minute quantities of soda by means of polarized light: by *T. Andrews*. Chem. Gaz. 1852, 378.
- Poppy.—Experiments on poppy-heads: by *A. Buchner*. J. Pharm. [3] xxii, 48; Pharm. J. Trans. xi, 416.
- Populine.—On populine: by *R. Piria*. Ann. Ch. Pharm. lxxxi, 245; Compt. rend. xxxiv, 138; Chem. Soc. Qu. J. v, 8.
- Optical observations on populine and on artificial salicine: by *MM. Biot and Pasteur*. Compt. rend. xxxiv, 606.
- Porcelain.—Researches on the composition of the substances used in the manufacture and decoration of porcelain in china: by *MM. Ebelmen and Salvétat*. Ann. Ch. Phys. xxxv, 312; Compt. rend. xxxiv, 647; Chem. Gaz. 1852, 428, 450, 469.
- Pork.—Analysis of the ash of unsalted pork: by *Echevarria*. Ann. Ch. Pharm. 373.
- Porphyrroxine.—On porphyrroxine or opine: by *M. Roberston*. J. Pharm. [3] xxii, 190.
- Potash.—On the variation in the relative proportion of potash and soda present in certain samples of barley, grown in plots of ground artificially impregnated with one or other of those alkalies: by *C. Daubeny*. Chem. Soc. Qu. J. v, 9; J. Pharm. [3] xxi, 435.
- On the preparation of pure hydrate and carbonate of potash: by *H. Wurtz*. Chem. Gaz. 1852, 203.
- On the double-salt of chromate of potash with cyanide of mercury: by *C. Rammelsbery*. Pogg. Ann. lxxxv, 145.
- On the composition of a series of hydrated silicates of ferric acid and potash: by *T. Scheerer*. Pogg. Ann. lxxxvii, 73.
- Potash-salts in blast iron-furnaces. J. Frank. Inst. [3] xxiii, 392.
- Potassium.—Researches on the extraction of potassium: by *Mareska and Donny*. Ann. Ch. Phys. [3] xxxv, 147.
- On an alloy of potassium and sodium: by *R. Wagner*. J. pr. Chem. lv, 489; Ann. Ch. Phys. [3] xxxvi, 246.
- Note on the commercial analysis of cyanide of potassium: by *J. Fordos and A. Gelis*. Compt. rend. xxxv, 224.
- On a curious form of crystallization of iodide of potassium: by *R. Warington*. Chem. Soc. Qu. J. v, 136.
- Potatoes.—On the amylum grains of the potatoe: by *A. Martin*. Phil. Mag. [4] iii, 277.
- On the fat of potatoes: by *H. Eichborn*. Pogg. Ann. lxxxvii, 227; Chem. Gaz. 1852, 461.

- Propylamine.—On some new double-salts of ethylamine and propylamine : by *M. Reckenschuss*. Ann. Ch. Pharm. lxxxiii, 343.
- Occurrence of propylamine in *Chenopodium vulvaria* : by *P. Dessaignes*. Ann. Ch. Pharm. lxxxi, 106.
- On the occurrence of propylamine : by *F. L. Winckler*. Chem. Gaz. 1852, 32).
- On the preparation of propylamine from ergot of rye : by *F. L. Winckler*. N. Repert. Pharm. i, 116, 171 ; J. Pharm. [3] xxii, 155 ; Pharm. J. Trans. xii, 42.
- Pseudo-Stearoptenes.—On the pseudo-stearoptenes found on the external surface of plants : by *M. Klotzsch*. J. Pharm. [3] xxi, 433.
- Pyroxyline.—Researches on pyroxyline (gun-cotton) : by *A. Bechamp*. Compt. rend. xxxv, 473.

Q.

- Quercite.—Reproduction of mannite and quercite from nitromannite and nitroquercite : by *P. Dessaignes*. Ann. Ch. Pharm. lxxxii, 251.
- Quinidine.—On quinidine : by *R. Howard*. Pharm. J. Trans. xi, 393.
- On the chemical composition of quinidine : by *H. G. Leers*. Ann. Ch. Pharm. lxxxii, 147 ; Ann. Ch. Phys. [3] xxxvi, 112 ; J. Pharm. [3] xxii, 239 ; Pharm. J. Trans. xii, 295.
- Quinine.—On the polarizing crystals produced by the action of iodine on sulphate of quinine : by *Dr. Herapath*. Phil. Mag. [4] iii, 161 ; iv, 186 ; Chem. Soc. Qu. J. v, 177 ; Pharm. J. Trans. xii, 6.
- On the three kinds of quinine : by *J. van Heiningen*. Pharm. J. Trans. xi, 521.
- On the fluorescence of quiniferous solutions. Pharm. J. Trans. xii, 245.
- On the adulterations of sulphate of quinine, and on the mode of testing it : by *A. Delondre* and *O. Henry*. J. Pharm. [3] xxi, 281 ; Pharm. J. Trans. xi, 393.
- Experiments for testing the purity of sulphate of quinine : by *M. Guibourt*. J. Pharm. [3] xxi, 47 ; Pharm. J. Trans. xi, 461.
- Mode of detecting sulphate of quinine in urine : by *Dr. Viale*. J. Pharm. [3] xxii, 303.
- Report presented to the “Académie de Médecine” on a memoir by *M. Barreswil* on the properties of tannate of quinine : by *MM. Orfila, Bussy* and *Bouvier*. J. Pharm. [3] xxi, 206.
- On the adulteration of sulphate of quinine : by *D. Zimmer*. Buchner's N. Repert. i, 443 ; Chem. Gaz. 1852, 450.
- Quinquina.—On the analysis of quinquinas : by *M. Riegel*. Arch. Pharm. [2] lxx, 40 ; J. Pharm. [3] xxii, 317.
- Analytical researches on the preparations of quinquina : by *M. Garot*. J. Pharm. [3] xxvi, 298.
- On the composition of the bark of *Quinquina royal* : by *M. Schwartz*. J. pr. Chem. lvi, 76 ; J. Pharm. [3] xxii, 394.

R.

- Radicals.—Researches on the oxygen radicals: by *L. Chiozza*. Ann. Ch. Pharm. lxxxiv, 102.
- Resins.—On the resins of Arbol-a-brea and of Elemi: by *S. Baup*. Pharm. J. Trans. xi, 313.
- On hircine, a new resin: by *H. Piddington*. Chem. Gaz. 1852, 213.
- On the resin of jalap and on perchlorinated succinic ether: by *A. Laurent*. Compt. rend. xxxv, 379.
- On the resin of jalap: by *W. Mayer*. Ann. Ch. Pharm. lxxxiii, 121.
- On a new fossil resin: by *J. W. Mallet*. Phil. Mag. [4] iv, 261.
- Respiration.—Researches on respiration and nutrition: by *M. Clement*. Compt. rend. xxxiv, 977.
- Rhatany.—On spurious rhatany root: by *Prof. Mettenheimer*. Pharm. J. Trans. xi, 420.
- Rocks.—Researches on the alterations of stratified rocks under the influence of atmospheric agents, and of infiltration-waters: by *M. Ebelmen*. Compt. rend. xxxiii, 678.
- On the composition and microscopic structure of certain basaltic and metamorphic rocks: by *T. Andrews*. Chem. Gaz. 1852, 416.
- Researches on globulous rocks (*roches globuleuses*): by *M. Delesse*. Compt. rend. xxxv, 274.
- On some modern calcareous rock-formations: by *J. D. Dana*. Sill. Am. J. [2] xiv, 410.
- Rubia.—Examination of the root of madder (*Rubia tinctorum*): by *Prof. Rochleder*. Ber. d. Akad. d. Wissensch. zu Wien, 1852; Ann. Ch. Pharm. lxxxii, 215; Chem. Gaz. 1852, 245.
- Rubiaceæ.—Examination of the *Rubiaceæ*: by *F. Rochleder*. Ber. Akad. Wissensch. zu Wien, math. phys. Classe, Jan. 1852; Ann. Ch. Pharm. lxxxiii, 64; Chem. Gaz. 1852, 291.
- Rubian.—On rubian and its products of decomposition: by *E. Schunck*. Phil. Trans. 1851, ii, 433; Ann. Ch. Pharm. lxxxi, 336; Phil. Mag. [4] iii, 213, 354; Ann. Ch. Phys. [3] xxxv, 366; Chem. Soc. Qu. J. v, 56.
- On the action of alkalies and earths on rubian: by *E. Schunck*. Chem. Gaz. 1852, 436.
- Rutania.—On the chemical analysis of the roots of *Rutania* and *Tormentilla*: by *M. Dause, sen.* J. Pharm. [3] xxi, 99.
- Rye.—On the detection of wheat-flour in rye-flour. Pogg. Ann. lxxxv, 145.

S.

- Safety-lamp.—Elvin's improved miners' safety-lamp. Phil. Mag. [4] iii, 239.
- Saffron.—On certain constituent principles of saffron (*Crocus sativus*): by *B. Quadrat*. J. Pharm. [3] xxii, 227.
- Salicin.—Optical observations on populin and on artificial salicin: by *MM. Biot and Pasteur*. Compt. rend. xxxiv, 606.
- Saline Solutions.—Observations on the supersaturation of saline solutions (conclusion): by *H. Löwel*. Ann. Ch. Phys. [3] xxxiii, 377.

- Saline Solutions.—Additional notes to his third memoir on the supersaturation of saline solutions: by *H. Löwel*. *Compt. rend.* xxxv, 219.
- Researches on the specific heat of saline solutions: by *C. C. Person*. *Ann. Ch. Phys.* [3] xxxiii, 437.
- Saliva.—Experimental researches on the secretion of saliva in ruminants: by *G. Colin*. *Compt. rend.* xxxiv, 681.
- Saltpetre.—On the production of saltpetre and soda in Hungary: by *J. Szabó*. *Arch. Pharm.* lxvi, 311; *Chem. Gaz.* 1852, 47.
- Sandal-wood.—On dyeing with sandal-wood: by *A. Wimmer*. *Chem. Gaz.* 1852, 235.
- Selenium.—On the allotropy of selenium: by *Hittorf*. *Pogg. Ann.* lxxxiv, 214; *Phil. Mag.* [4] iii, 546; *Chem. Soc. Qu. J.* v, 90.
- Sherbet.—On the sherbets of the East: by *X. Landerer*. *Pharm. J. Trans.* xi, 407.
- Silica.—On the solubility and hydrated state of silicic acid: by *J. Fuchs*. *Ann. Ch. Pharm.* lxxxii, 119.
- Silicates.—On the classification of the silicates and their allied compounds: by *E. J. Chapman*. *Phil. Mag.* [4] iii, 270.
- On the composition of a series of hydrated silicates of ferric oxide and potash: by *T. Scheerer*. *Pogg. Ann.* lxxxvii, 73.
- Note on a hydrosilicate of soda which is found cementing a mass of breccia in the neighbourhood of Sablonville: by *L. Kraft* and *N. B. Delahaye*. *Compt. rend.* xxxv, 143.
- Silk-worm.—Chemical and physiological researches on silk-worms: by *E. Pélilot*. *Compt. rend.* xxxiv, 290.
- Silver.—On a peculiar brittle form of silver: by *A. and W. Knop*. *Chem. Pharm. Centralb.* 1852, 530; *Chem. Gaz.* 1852, 344.
- Preparation of pure silver from the chloride: by *C. Brunner*. *Pogg. Ann.* lxxxii, 462; *Phil. Mag.* [4] iv, 78.
- On peroxide of silver: by *F. Mahla*. *Ann. Ch. Pharm.* lxxxii, 253; *Ann. Ch. Phys.* [3] xxxvi, 231; *Phil. Mag.* [4] iv, 319; *Chem. Gaz.* 1852, 261.
- On the compounds of carbonic acid with oxide of silver: by *H. Rose*. *Pogg. Ann.* lxxxv, 312.
- On the compounds of the oxides of cadmium and silver with carbonic acid: by *H. Rose*. *Chem. Gaz.* 1852, 181.
- Solubility of chloride of silver in mercuric nitrate. *Ann. Ch. Pharm.* lxxxi, 128.
- Observations on the double cyanide of potassium and silver, and on its function in electro-chemistry: by *H. Bouilhet*. *Ann. Ch. Phys.* [3] xxxiv, 153.
- On the mode of separating in a state of purity, from melting silver, the oxygen which it has observed from the air: by *M. Levol*. *J. Pharm.* [3] xxii, 290; *Compt. rend.* xxxv, 63; *Pogg. Ann.* lxxxvii, 320.
- On the preparation of *Lapis infernalis*; by *M. Mohr*. *J. Pharm.* [3] xxii, 314.
- On electro-plating: by *E. Thomas* and *V. Delisse*. *Compt. rend.* xxxiv, 556; *Chem. Gaz.* 1852, 415.
- Note on electro-chemical plating, in reply to MM. Thomas and Delisse: by *H. Bouilhet*. *Compt. rend.* xxxiv, 580.

Silver.—Note on a new alloy of silver: by *G. Barruel*. *Compt. rend.* xxxv, 759.
 — Improvements in obtaining silver from the residuum in the manufacture of oxychloride of lead (Patterson's patent). *Pharm. J. Trans.* xii, 304.
 — Improvements in separating gold and silver from other metals (Parkes' patent). *Pharm. J. Trans.* xii, 304.

Sinapine.—On sinapine: by *L. Babo* and *M. Hirschbrunn*. *Ann. Ch. Pharm.* lxxxiv, 10.

Slag.—Application of the slag of blast-furnaces to the preparation of alum, chloride of calcium, &c. *Pharm. J. Trans.* xii, 259.

Slate.—Chemico-mineralogical investigation of the Taunus slate: by *K. List* (conclusion). *Ann. Pharm.* lxxxi, 257.

Soda.—Analysis of crude soda: by *B. Unger*. *Ann. Ch. Pharm.* lxxxi, 289.

— On the detection of minute quantities of soda by means of polarized light: by *T. Andrews*. *Chem. Gaz.* 1852, 379.

— On the variation in the relative proportion of potash and soda present in certain samples of barley, grown in plots of ground artificially impregnated with one or other of those alkalies: by *C. Daubeny*. *Chem. Soc. Qu. J.* v, 9.

— Improvements in the manufacture of hydrate and carbonate of soda. *Pharm. J. Trans.* xii, 141.

— On the production of saltpetre and soda in Hungary: by *J. Szabó*. *Arch. Pharm.* lxvi, 311; *Chem. Gaz.* 1852, 47.

— On the composition of arseniate of soda: by *M. Fresenius*. *J. Pharm.* [3] xxii, 226; *J. pr. Chem.* lvii, 30.

— On the pyrophosphate of soda and iron: by *A. Ure*. *J. Pharm.* [3] xxi, 297.—Also by *L. Blyth*. *Pharm. J. Trans.* xi, 456.

— Historic notice relating to the discovery of the *soude artificielle* of MM. Leblanc and Dizé: by *F. Boudet*. *J. Pharm.* [3] xxii, 99.

— On stannate of soda. *Chem. Gaz.* 1852, 459.

— Preparation of nitroprussiate of soda: by *E. Roussin*. *Pharm. J. Trans.* xii, 44.

Sodium.—On an alloy of potassium and sodium: by *R. Wagner*. *J. pr. Chem.* lv, 489; *Ann. Ch. Phys.* [3] xxxvi, 246.

— Contribution to the chemical history of nitroprusside of sodium: by *C. Rammelsberg*. *Pogg. Ann.* lxxxvii, 107.

— On the decomposition of the so-called nitroprusside of sodium by the solar rays: by *A. Overbeck*. *Pogg. Ann.* lxxxvii, 110.

Soils.—Researches on the composition of the soluble matters extracted by water from fertile soils: by *F. Verdeil* and *E. Risler*. *Compt. rend.* xxxv, 95.

— Notes and observations on the analyses and character of the soil of Scioto Valley, Ohio, with some general considerations respecting the analyses of soils: by *D. A. Wells*. *Sill. Am. J.* [2] xiv, 11.

Solids.—New developments relating to the chemical effects produced by the contact of solids and liquids: by *M. Becquerel*. *Compt. rend.* xxxiv, 573.

Sorbine.—On sorbine, a new saccharine substance extracted from the berries of the mountain-ash: by *J. Pelouze*. *Ann. Ch. Phys.* [3] xxxv, 223; *Ann. Ch. Pharm.* lxxxiii, 47; *J. Pharm.* [3] xxi, 321; *Chem. Soc. Qu. J.* v, 281.

- Spartium*.—On the action of nitric acid on various vegetables, with a more particular reference to *Spartium scoparium*: by J. Stenhouse. Phil. Trans. 1851, ii, 415.
- Spermaceti.—On spermaceti: by W. Heintz. Pogg. Ann. lxxxvii, 21, 267.
- Spheroidal state.—On the force which sustains the drops of liquid in Leidenfrost's experiment: by C. C. Person. Pogg. Ann. lxxxiv, 274.
- Spiræa*.—Contributions to the physiology of the *Spiræas*: by W. Wicke. Ann. Ch. Pharm. lxxxiii, 175.
- Spiræa ulmaria*.—Report presented to the "Société de Pharmacie," on the preparations of *Spiræa ulmaria*: by M. Garot. J. Pharm. [3] xxi, 288.
- Stalactites.—On the existence of organic matter in stalactites and stalagmites, forming crystallized and amorphous crenate of lime: by D. A. Wells. Chem. Gaz. 1852, 72.
- Stannates.—On stannate of soda. Chem. Gaz. 1852, 459.
- Stannethyl.—On stannethyl, a new organic radical containing tin: by A. Cahours and R. Riche. Compt. rend. xxxv, 9; Chem. Gaz. 1852, 307.
- Starch.—On iodide of starch, and its decoloration by heat and by vegetable charcoal: by M. Lahens. J. Pharm. [3] xxi, 13.
- On soluble iodide of starch, and the mode of preparing it: by M. Lefort. J. Pharm. [3] xxi, 202.
- On soluble iodide of starch and syrup of iodide of starch: by M. Lefort. J. Pharm. [3] xxi, 340.
- Steam.—Note on the use of aqueous vapour in certain metallurgic operations by M. Cumerge. Ann. Men. [5] i, 425.
- On the use of vapour of water for extinguishing fires: by M. Dujardin. Compt. rend. xxxiv, 487.
- On the distillation of oil of cloves, and the preparation of benzoic acid by means of superheated steam: by E. A. Scharling. Pharm. J. Trans. xi, 469.
- Steam-engine.—Note on a disputed question connected with the history of the steam-engine: by J. Appjoha. Chem. Gaz. 1852, 396.
- Stearine.—On the manufacture of stearine candles by distillation; question of priority. Letter to the editor: by MM. Bussy and Lecann. J. Pharm. [3] xxi, 279.
- On the stearic candle manufacture: by G. F. Wilson. Chem. Gaz. 1852, 119.
- Steel.—On the tempering of steel: by X. Landerer. J. Pharm. [3] xxi, 302.
- On the composition of wootz, or Indian steel: by T. H. Henry. Phil. Mag. [4] iv, 42.
- Stibethyl.—On the indirect bleaching power of stibethyl: by C. F. Schönbein. J. pr. Chem. lvi, 353; Phil. Mag. [4] iv, 239.
- Stibmethylum.—On stibmethylum and its compounds: by H. S. Landolt. Mittheil. d. Naturforsch. Gesellsch. in Zürich, Nos. 72, 73, 74; Ann. Ch. Pharm. lxxxiv, 44; Chem. Gaz. 1852, 381, 404.
- Stratification.—Observations on the origin of stratification: by D. A. Wells. Sill. Am. J. [2] xiii, 13.
- Strontia.—Note on the existence of strontia in the well-waters of Bristol: by W. and T. J. Herapath. Chem. Soc. Qu. J. v, 193.

- Strontia.**—Action of baryta and strontia on the compounds of titanium before the blowpipe: by *E. J. Chapman*. Chem. Gaz. 1852, 297.
- Strychnine.**—On the methods adopted for detecting the presence of strychnine: by *J. Lefort*. J. Pharm. [3] xxi, 172.
- Report upon the alleged adulteration of pale ales by strychnine: by *Professors Graham and Hofmann*. Chem. Soc. Qu. J. v, 173; Ann. Ch. Pharm. lxxxiii, 39; Pharm. J. Trans. xi, 504; Chem. Gaz. 1852, 197.
- On the use of chlorine as an antidote to strychnine: by *M. Bandet*. Ann. Ch. Phys. [3] xxxv, 464.
- Sublimation.**—A modification of the ordinary process of sublimation in a straight tube: by *R. Warington*. Chem. Soc. Qu. J. v, 141.
- Sugar.**—Improvement in the manufacture and refining of sugar: by *R. and J. Oxland*. Chem. Gaz. 1852, 38.
- On a peculiar kind of sugar in acorns: by *P. Dessaignes*. Ann. Ch. Pharm. lxxxi, 103.
- Transformation of mannite into sugar: by *M. L'Hermite*. Compt. rend. xxxiv, 114.
- On the action exerted by acids, by heat, and by alkaline and earthy chlorides on oil of turpentine and its hydrate, on sugar and on alcohol: by *M. Berthelot*. Compt. rend. xxxiv, 799; Ann. Ch. Pharm. lxxxiii, 106.
- On Soleil's polariscope, for determining the quantity of sugar in a solution: by *H. Bence Jones*. Pharm. J. Trans. xi, 455.
- On the behaviour of the nitrogenous compounds of sugar with reducing agents: by *A. and W. Knop*. Pharm. Centrbl. xxiii, 423; Chem. Gaz. 1852, 295.
- On the presence of sugar in urine: by *M. Barreswil*. J. Pharm. [3] xxi, 27.
- On the quantity of sugar in the carrot (*Daucus carrota*), and its alcoholic and nutritive equivalents; by *C. Schmidt*. Ann. Ch. Pharm. lxxxiii, 325.
- Absence of sugar in the urine of hysterical and epileptic patients, some hours after the attacks: by *M. Michéa*. Compt. rend. xxxiii, 669.
- Presence of sugar in the urine of hysterical and epileptic patients: by *A. Reynoso*. Compt. rend. xxxiv, 18.
- Sulphates.**—On the conversion of alkaline sulphates into chlorides: by *H. Rose*. Pogg. Ann. lxxxv, 443.
- On the commercial manufacture of sulphate of iron. Pharm. J. Trans. xi, 568.
- On the polybasic sulphates of the magnesian series: by *M. Schaeffele*. J. Pharm. [3] xxi, 81.
- New experiments on the influence of sulphates on the yield of artificial meadows with leguminous bottom: by *J. I. Pierre*. Ann. Ch. Phys. [3] xxxvi, 61.
- Note on the use of sulphate of iron for the disinfection of manure, and on the solubility of the phosphates of iron: by *J. I. Pierre*. Ann. Ch. Phys. [3] xxxvi, 70.
- Observations on the treatment of the sulphates of potash and soda by oxide of carbon: by *M. Levol*. J. Pharm. [3] xxii, 289.

- Sulphates.—On the preparation of sulphate of alumina: by *MM. Huria and Brunel*. Bull. Soc. d'Encourag. 1852, 199; Chem. Gaz. 1852, 359.
- Sulphides.—Researches on the sulphides decomposable by water: by *E. Fremy*. Compt. rend. xxxv, 27; J. Pharm. [3] xxii, 241; Phil. Mag. [4] iv, 153.
- On a compound of sulphur, nickel and bismuth: by *G. Werther*. J. pr. Chem. lv, 227; Chem. Gaz. 1852, 252.
- On the manufacture of sulphide of carbon: by *M. Girard*. Compt. rend. xxxv, 257.
- Sulphites.—On a method of separating the alkaline sulphites from alkaline carbonates, sulphates and hyposulphites: by *G. Werther*. J. pr. Chem. lv, 22; Chem. Gaz. 1852, 157.
- On several new sulphites of mercuric oxide and cuprous oxide: by *L. Péan de Saint-Gilles*. Ann. Ch. Phys. [3] xxxvi, 80; Compt. rend. xxxiv, 905.
- On the compounds of certain essential oils with the alkaline bisulphites: by *C. Bertagnini*. Compt. rend. xxxv, 801; Chem. Soc. Qu. v, 317.
- Sulphocyanides.—Action of certain oxidizing and deoxidizing agents on the sulphocyanide of potassium, and on ferrous and ferric sulphocyanides: by *M. Besanou*. J. Pharm. [3] xxii, 161.
- On sulphocyanide of ammonium as a test for iron-salts. J. Pharm. [3] xxi, 295; Pharm. J. Trans. xi, 296.
- Sulphostannates.—On the sulphostannates: by *O. B. Kühn*. Ann. Ch. Pharm. lxxxiv, 110.
- Sulphur.—On the sulphur deposits at Swaszowicze and Radoboj. Phil. Mag. [4] iii, 157.
- On the quantitative determination of sulphur: by *W. Heintz*. Pogg. Ann. lxxxvi, 424; Chem. Gaz. 1852, 375.
- Note on certain properties of sulphur: by *C. Sainte-Claire Deville*. Compt. rend. xxxiv, 534.
- On certain properties of sulphur: by *M. Payen*. Compt. rend. xxxiv, 534.
- Detection of small quantities of sulphur: by *J. W. Bailey and J. D. Dana*. Ann. Ch. Pharm. lxxxi, 180.
- Researches on the dimorphism and transformation of sulphur: by *C. Sainte-Claire Deville*. Compt. rend. xxxiv, 561.
- On pseudosoluble sulphur, on its pseudosolution, and on soft sulphur: by *M. Selmi*. J. Pharm. [3] xxi, 418.
- On a new compound of the highest chloride of sulphur with sulphuric acid: by *H. Rose*. Pogg. Ann. lxxxv, 510.
- Sulphur in pyroligneous spirit: by *Reuben Phillips*. Chem. Gaz. 1852, 252.
- On the influence of sulphur on the properties of cast iron: by *M. Janoyer*. Ann. Min. [4] xx, 359; Chem. Gaz. 1852, 227.
- Extract from a memoir on the sulphuration of caoutchouc, and on certain properties of sulphur: by *M. Payen*. Compt. rend. xxxiv, 453; J. Pharm. [3] xxi, 366.
- On anisated balsam of sulphur: by *E. Robiquet*. J. Pharm. [3] xxi, 200.
- Reduction of metals by phosphorus and sulphur: by *W. Wieke*. Ann. Ch. Pharm. lxxxii, 145.
- Researches on the densities of sulphur: by *C. Bramé*. Compt. rend. xxxv, 748.

Syrups.—On the means of detecting the presence of syrup of fecula in the syrups of sugar of commerce : by *E. Soubeiran*. Pharm. J. Trans. xi, 366.

T.

Tannin.—On tannins and glucosamides : by *A. Laurent*. Compt. rend. xxxv, 161.

Tartrates.—On the preparation of the double tartrate of potash and iron (*boules de Nancy*) : by *M. Winckler*. J. Pharm. [3] xxii, 319.

— Method of preparing ferrico-potassic tartrate in pellets : by *MM. Carnélis and Gilles*. J. Pharm. [3] xxii, 304.

Tea.—On the teas of commerce : by *R. Warington*. Ann. Ch. Pharm. lxxxi, 228.

— Some additional observations on the green teas of commerce : by *R. Warington*. Chem. Soc. Qu. J. v, 139.

Tellurium.—Observations on telluride of ethyl : by *W. Mallet*. Chem. Soc. Qu. J. v, 71.

— On some new compounds of tellurethyl : by *F. Wöhler*. Ann. Ch. Pharm. lxxxiv, 69.

Thalia.—On *Thalia*, a new earth, discovered in the new American mineral *Thalite* : by *D. Owen*. Sill. Am. J. [2] xiii, 420.

Thermometry.—On thermometry and subjects therewith connected : by *Plücker and Geissler*. Pogg. Ann. lxxxvi, 238.

Thorina.—On thorina and donaria : by *M. Damour* and *Prof. Berlin*. Pogg. Ann. lxxxv, 556.

— On thorina and donaria : by *Prof. Bergemann*. Pogg. Ann. lxxxv, 558.

Thorinum.—Chemical researches on a new oxide obtained from a Norwegian mineral; examination and analysis of *Orangite* : by *A. Damour*. Compt. rend. xxxiv, 685.

Tin.—On the occurrence of tin in Spain : by *E. L. Schubarth*. Pogg. Ann. lxxxvi, 600.

— On the detection and qualitative separation of tin, antimony and arsenic; and on the relation existing between these metals, and others which are precipitated from their acid solutions by sulphuretted hydrogen : by *C. L. Bloxam*. Chem. Soc. Qu. J. v, 104; Ann. Ch. Pharm. lxxxiii, 180.

— On the qualitative separation of tin, antimony, and arsenic : by *G. F. Ansell*. Chem. Soc. Qu. J. v, 210.

— New method of precipitating oxide of tin, and separating it from other bodies, and of combining it with silk, woollen, and cotton fabrics : by *J. Löwenthal*. J. pr. Chem. lvi, 366; Chem. Gaz. 1852, 340.

— On bichloride of tin and some of its compounds : by *W. Casselmann*. Ann. Ch. Pharm. lxxxiii, 257.

— On the corrosion of the tin cooling tubes in copper coolers : by *F. A. Wolff*. Ann. Ch. Pharm. lxxxi, 374.

— On the sulphostannates : by *O. B. Kuhn*. Ann. Ch. Pharm. lxxxiv, 110.

— Researches on stannethyl, a new organic radical containing tin : by *A. Cahours* and *A. Riche*. Compt. rend. xxxv, 91.

— On a remarkable deposit of tin-ore at the Providence Mines, near St. Ives, Cornwall : by *W. J. Henwood*. Phil. Mag. [4] iv, 538.

Toad.—On the urine of the toad (*Bufo cinereus*) : by *O. Hautz*. Ann. Ch. Pharm. lxxxiv, 127.

— On the urine of the toad (*Bufo cinereus*) : by *O. Hautz*. Ann. Ch. Pharm. lxxxiv, 127.

- Tolu-balsam.**—Report on a method of preparing the syrup of tolu-balsam proposed by M. Matthieu : by *M. Dublanc*. J. Pharm. [3] xxii, 119.
- Tormentilla.**—On the chemical analysis of the roots of *Ratanhia* and *Tormentilla* : by *M. Danse, sen.* J. Pharm. [3] xxi, 99.
- Trimethylamine.**—On the presence of trimethylamine in herring-brine : by *A. W. Hofmann*. Compt. rend. xxxv, 62 ; Ann. Ch. Pharm. lxxxiii, 116 ; Chem. Soc. Qu. J. v, 288 ; Pharm. J. Trans. xii, 198.
- Titanium.**—Researches on the crystalline forms and chemical and physical properties of titanic acid and other isomorphous oxides : by *M. Ladrey*. Compt. rend. xxxiv, 56.
- Action of baryta and strontia on the compounds of titanium before the blow-pipe : by *E. J. Chapman*. Chem. Gaz. 1852, 297.
- Titanium in the waters of Neyrac (Ardèche) : by *M. Mazade*. Compt. rend. xxxiv, 952.
- Tungsten.**—On the atomic weight of tungsten and on some of its compounds : by *J. B. von Borch*. J. pr. Chem. liv, 254 ; Chem. Gaz. 1852, 95.
- Researches on the composition of wolfram : by *J. Persoz*. Compt. rend. xxxiv, 135 ; Chem. Soc. Qu. J. v, 95.
- On phosphide of tungsten : by *F. Wöhler*. Chem. Soc. Qu. J. v, 94.
- Artificial preparation of crystallized tungstate of lime : by *N. S. Manross*. Ann. Ch. Pharm. lxxxi, 243.
- Turpentine.**—On the action exerted by acids, by heat, and by alkaline and earthy chlorides on oil of turpentine and its hydrate, and on sugar and alcohol : by *M. Berthelot*. Compt. rend. xxxiv, 799 ; J. Pharm. [3] xxxi, 31 ; Ann. Ch. Pharm. lxxxiii, 106.
- On a new compound of oil of turpentine : by *A. Sobrero*. Ann. Ch. Pharm. lxxx, 106.
- On certain products obtained from oil of turpentine : by *J. Chautard*. Compt. rend. xxxiv, 485.
- On the bi-hydrochlorate of turpentine : by *M. Berthelot*. Compt. rend. xxxv, 736.
- Tyrosin.**—On tyrosin : by *R. Piria*. Ann. Ch. Pharm. lxxxii, 251.
- U.
- Ulmates.**—On the absorption of soluble ulmates by plants : by *J. Malaguti*. Compt. rend. xxxiv, 112.
- Ultramarine.**—New method of testing ultramarine : by *Dr. Bernheim*. Centralblatt. March 3, 1852 ; Chem. Gaz. 1852, 174.
- Uranium.**—On the compounds of sesquioxide of uranium with acids : by *A. Girard*. Compt. rend. xxxiv, 22 ; Ann. Ch. Pharm. lxxxii, 366 ; Chem. Gaz. 1852, 41 ; J. Pharm. [3] xxi, 18.
- Preparation of oxide of uranium for technical purposes : by *C. Giselle*. Arch. Pharm. [2] lxix, 150 ; Chem. Gaz. 1852, 174.
- Urea.**—Test for urea : by *J. Liebig*. Ann. Ch. Pharm. lxxx, 123 ; J. Pharm. [3] xxi, 413 ; Pharm. J. Trans. xi, 353.
- Urethane.**—On the composition of urethane and urethylane : by *R. Wagner*. J. pr. Chem. liii, 121 ; J. Pharm. [3] xxi, 235.
- Uric Compounds.**—On uric, chlorosulphalic and percarbonic compounds : by *A. Laurent*. Compt. rend. xxxv, 629.

- Urine.—On the proximate principles of human urine: by *W. Marcet*. Bibl. Univ. 1852, 144; Chem. Gaz. 1852, 347.
- Researches on the colouring principle of urine; existence of iron in that liquid: by *G. Harley*. Pharm. J. Trans. xii, 243.
- Causes of the passage of albumin into the urine: by *E. Robin*. Compt. rend. xxxiii, 698.
- Phosphoric acid in normal human urine: by *D. Breed*. Sill. Am. J. [2] xiii, 224.
- On the triple or ammonio-magnesian phosphates occurring in the urine and other animal fluids: by *J. W. Griffith*. Phil. Mag. [4] iii, 373.
- On the occurrence of creatinine in calves' urine: by *N. Socoloff*. Ann. Ch. Pharm. lxxx, 114.
- Examination of urine in dropsy: by *C. Neubauer*. Arch. Pharm. [2] lxix, 293; Chem. Gaz. 1852, 258.
- Examination of a cystic calculus and cystic urine: by *J. Müller*. Arch. Pharm. [2] lxix, 328; J. Pharm. [3] xxii, 76.
- Absence of sugar in the urine of hysterical and epileptic patients, some hours after the attacks: by *M. Michéa*. Compt. rend. xxxiii, 669.
- Presence of sugar in the urine of hysteric and epileptic patients: by *A. Reynoso*. Compt. rend. xxxiv, 18.
- Detection of sulphate of quinine in urine: by *Dr Viale*. J. Pharm. [3] xxii, 303.
- On the urine of the toad (*Bufo cinereus*): by *O. Hautz*. Ann. Ch. Pharm. lxxxiv, 127.

V.

- Vacuum.—On a method of obtaining a perfect vacuum in the receiver of an air-pump: by *T. Andrews*. Phil. Mag. [4] iii, 104; Chem. Soc. Qu. J. v, 189.
- Note on an apparatus for producing a vacuum: by *C. Fontaine*. Compt. rend. xxxiv, 408.
- Vegetable Substances.—On the preservation of animal and vegetable substances: by *Gail. Borden, jun.* Chem. Gaz. 1852, 179.
- Vegetation.—Experimental researches on vegetation (3rd part); influence of ammonia added to the air, on the development of plants; by *M. Ville*. Compt. rend. xxxv, 650.
- Ventilation.—Further observations on the ventilation and warming of rooms: by *S. Webber*. Sill. Am. J. [2] xiv, 182.
- Vine.—On the inorganic constituents of the vine: by *Berthier*. Ann. Ch. Phys. [3] xxxiii, 249; Ann. Ch. Pharm. lxxxii, 133.
- Vinegar.—On the manufacture of vinegar: by *Professors Graham, Hofmann and Playfair*. Pharm. J. Trans. xii, 293.
- On the preparation of pure acetic acid from wood-vinegar and brandy-vinegar: by *C. Fölckel*. Ann. Ch. Pharm. lxxxii, 49; Chem. Soc. Qu. J. v, 274.
- On the nature and chemical action of *mother-of-vinegar*: by *R. D. Thomson*. Ann. Ch. Pharm. lxxxiii, 89.
- Violets.—Observations on syrup of violets: by *M. Huraut-Montillard*. J. Pharm. [3] xxii, 5.

Vital Affinity.—Defence of the doctrine of vital affinity against the objections stated to it by Humboldt and Daubeny: by *Dr. Alison*. Proc. Roy. Soc. Edinb. 1851-2, 105.

W.

- Water.—On the volume of water at different temperatures, according to Pierre's experiments: by *L. Frankenheim*. Pogg. Ann. lxxxvi, 451.
- On water of crystallization, its relation to the constitution and solubility of salts, and its behaviour in chemical reactions: by *P. Kremers*. Pogg. Ann. lxxxvi, 375.
- On the influence of water on chemical reactions: by *H. Rose*. Pogg. Ann. lxxxiv, 461, 547; lxxxv, 107, 304; lxxxvi, 99, 279, 465, 561; lxxxvii, 1.
- Compounds of carbonic acid and water with sesquioxide of cobalt, lxxxiv, 547.—Compounds of carbonic acid and water with oxide of zinc, lxxxv, 107.—Compounds of carbonic acid and water with oxide of cadmium, *ibid.* 304.—Compounds of carbonic acid and water with oxide of silver, *ibid.* 302.—General observations on the action of water on carbonic acid and its salts, lxxxvi, 99, 279.—Action of water on boracic acid and its salts, *ibid.* 465.—Compounds of boracic acid and water with lime, *ibid.* 561.—Compounds of boracic acid and water with baryta, lxxxvii, 1.
- Action of water at a high temperature and under strong pressure on the pyrophosphates, metaphosphates, cyanides, &c.: by *A. Reynoso*. Compt. rend. xxxiv, 795.
- On the action of water at high pressure and temperature on certain compounds: by *A. Reynoso*. Ann. Ch. Pharm. lxxxiii, 98.
- On the amount of water contained in the tribasic phosphate of lime: by *H. Ludwig*. Arch. Pharm. [2] lxi, 286; Chem. Gaz. 1852, 367.
- On the physical and chemical constitution of natural waters: by *E. Marchand*. Compt. rend. xxxiv, 54.
- On a method of detecting the presence of water in various substances, and on the dehydration of alcohol: by *A. Gorgeu*. Compt. rend. xxxiii, 690; J. Pharm. [3] xxi, 259.
- Analysis of the water of rain, snow and dew: by *F. Meyrac*. Compt. rend. xxxiv, 714.
- Examination of the chemical constitution of rain-water at different times of the year: by *M. Barral*. Compt. rend. xxxiv, 58.
- Second memoir on the rain-water collected at the Observatoire de Paris: by *M. Barral*. Compt. rend. xxxv, 427; Phil. Mag. [4] iv, 396.
- Red rain fallen at Rheims; examination of the water: by *M. Cahours*. Compt. rend. xxxv, 832.
- Foreign substances in rain-water collected in Paris and Lyons. Pogg. Ann. lxxxvi, 332.
- Analysis of the water supplied by the Winchester Water-works Company: by *T. J. and W. Herapath*. Chem. Gaz. 1852, 212.
- Note on the existence of strontia in the well-waters of Bristol: *W. and T. J. Herapath*. Chem. Soc. Qu. J. v, 193.
- Examination of water used in irrigation: by *Chevaudier and Salvétat*. Ann. Ch. Phys. [3] xxxiv, 301.
- Notice respecting the analysis of mineral waters containing magnesia: by *H. Tilmanns*. Ann. Ch. Pharm. lxxxi, 369.

- Water.—Comparative research of iodine and certain other matters in the waters which supply Paris, London and Turin: by *A. Chatin*. *Compt. rend.* xxxv, 46, 127.
- On the physical constitution of potable waters, and their influence upon the development of goitre and cretinism: by *M. Marchand*. *Compt. rend.* xxxiv, 178; *J. Pharm.* [3] xxi, 94.
- General considerations on thermal waters: by *C. Blondeau*. *J. Pharm.* [3] xxii, 265.
- Report on M. Filhol's memoir entitled "Researches on the sulphuretted mineral waters of Bagnères-de-Luchon and Labassère, followed by general considerations on the sulphuretted waters of the Pyrenees:" by *M. Balard*. *Compt. rend.* xxxv, 37.
- Analysis of the mineral water of Cuèse in Savoy: by *M. Pyrame Marin*. *J. Pharm.* [3] xxi, 5.
- Analysis of the water of the Dead Sea and the river Jordan: by *MM. Boutron-Charlard and Henry*. *J. Pharm.* [3] xxi, 161.
- Mineral, sulphurous and thermal water of St. Honoré (Nièvre): by *O. Henry*. *J. Pharm.* [3] xxi, 401.
- Analysis of the mineral water of Jenzat (Allier): by *M. Lefort*. *J. Pharm.* [3] xxi, 340.
- On the mineral waters of Mytilene: by *X. Landerer*. *J. Pharm.* [3] xxi, 215.
- On the detection of nickel and cobalt in the mineral waters of Nérac (Ardèche), by *M. Mazade*. *Compt. rend.* xxxiv, 479.
- Titanium and zirconium in the waters of Neyrac (Ardèche): by *M. Mazade*. *Compt. rend.* xxxiv, 952; xxxv, 258.
- On the external and internal relations of the aerated thermal waters at Nauheim: by *C. Bromeis*. *Ann. Ch. Pharm.* lxxxi, 129.
- On the petrifying waters of Salles-la-Source and the sulphuretted waters of Pont (Aveyron): by *C. Blondeau*. *Compt. rend.* xxxv, 147.
- Composition of the Schlangenbad water: by *Fresenius*. *Ann. Ch. Pharm.* lxxxiii, 252.
- Analysis of the mineral waters of Wiesbaden and Ems: by *Fresenius*. *Ann. Ch. Pharm.* lxxxii, 249.
- Chemical examination of the sulphureous spring at Weilbach in the Duchy of Nassau: by *H. Will*. *Ann. Ch. Pharm.* lxxxi, 93.
- Researches on the incrustation of boilers fed with sea-water: by *M. Couste*. *Compt. rend.* xxxv, 186.
- Wax.—On the detection and estimation of stearic acid in bees'-wax: by *M. Overbeck*. *J. Pharm.* [3] xxi, 39.
- On the oxidation of Chinese wax: by *N. S. Maskelyne*. *Chem. Soc. Qu. J.* v, 24.
- Weapons.—Chemical examination of certain coins and weapons of the ancient: by *J. A. Phillips*. *Ann. Ch. Pharm.* lxxxi, 206.
- Weight.—On a process for the rigorous adjustment of weights intended for very exact weighings: by *M. Deleuil*. *Compt. rend.* xxxiv, 212.
- Wheat.—On the detection of wheat-flour in rye-flour. *Pogg. Ann.* lxxxv, 145.
- Wine.—On the bouquet of wine: by *F. L. Winckler*. *Jahrb. f. prakt. Pharm.* xxv, 7; *Pharm. J. Trans.* xii, 255.

- Wood.—On the manufacture of gas from wood : by *Dr. Pettenkofer*. *Centralb.* Mar. 10, 1852; *Chem. Gaz.* 1852, 179.
- On the occurrence of metallic iron in fossil-wood : by *W. G. Lettsom*. *Phil. Mag.* [4] iv, 333; *J. pr. Chem.* liv, 194; *J. Pharm.* [3] xxi, 233.
- On the occurrence of berberine in Columbo wood (*Menispermum* [*Coscinium*] *fenestratum*.) *Ann. Ch. Pharm.* lxxxiii, 276. *Phil. Mag.* [4] iv, 99; *Pharm. J. Trans.* xii, 188.
- Wood-spirit.—Sulphur in pyroligneous spirit : by *Reuben Phillips*. *Chem. Gaz.* 1852, 252.
- Woody Fibre.—Origin and composition of woody fibre and of the fibres of the *liber* : by *A Trécul*. *Compt. rend.* xxxv, 248.
- Wootz.—On the composition of wootz, or Indian steel : by *T. H. Henry*. *Phil. Mag.* [4] iv, 42.

Y.

- Yeast.—Analysis of yeast from Mr. Thomson's baking-house at Glasgow : by *R. D. Thomson*. *Ann. Ch. Pharm.* lxxxii, 372.
- On the quantity of yeast used in making bread : *Ann. Ch. Pharm.* lxxxii, 371.

Z.

- Zinc.—On the supposed crystallization of zinc in forms of the regular system : by *G. Rose*. *Pogg. Ann.* lxxxv, 293.
- On the amalgamated zinc of constant batteries : by *M. Nicklès*. *J. Pharm.* [3] xxi, 266.
- On oxide of zinc : by *Dr. Wittstein*. *Pharm. J. Trans.* xi, 571.
- On the occurrence of crystalline zinc-oxide as a furnace-product : by *W. P. Blake*. *Sill. Am. J.* ii, xiii, 417.
- On the compounds of carbonic acid and water with oxide of zinc : by *H. Rose*. *Pogg. Ann.* lxxxv, 107.
- Improvements in obtaining chloride of zinc, carbonate of soda, &c. *Pharm. J. Trans.* xii, 142.
- Action of chloride of zinc on cellulose : by *M. Barreswil*. *J. Pharm.* [3] xxi, 205.
- Etherification by chloride of zinc. *J. Pharm.* [3] xxi, 37.
- Zinc.—Note on white lead compared with zinc-white : by *M. Fersepey*. *Compt. rend.* xxxv, 103.
- Use of sulphate of zinc for the preservation of animal substances. *Compt. rend.* xxxiv, 58, 111.
- Zirconia.—Zirconia in the waters of Neyrac (Ardèche) : by *M. Mazade*. *Compt. rend.* xxxiv, 952.

INDEX.

A.

Acetic benzoate, or benzoic acetate, 227.
 — chloride, 226.
 — cuminate, or cuminic acetate, 227.
 Acid acetic, anhydrous, 129, 228.
 — on the preparation of pure, from wood-vinegar and brandy-vinegar, by C. Völckel, 274.
 — aceto-propionic, 4.
 — anthrinilic, difference between, and benzoic acid, 134.
 — apophyllic, 266.
 — aspartic, active and inactive, 63.
 — benzoic, anhydrous, 129, 228.
 — benzoglycolic, products of decomposition of, 79.
 — benzoglycolic, salts of, 75, 78.
 — benzolactic, 82.
 — capric, on the occurrence of, in some fusel-oils, by T. H. Rowney, 22.
 — caprylic, on the occurrence of, in some fusel-oils, by T. H. Rowney, 22.
 — citric, on the constitution of, by L. Pebal, 284.
 — citrobianilic, 286.
 — citromonanilic, bibasic, silver-salt of, 288.
 — monobasic, 287,
 — silver-salt of, 287.
 — aniline-salt of, 288.
 — cuminic, anhydrous, 228.
 — glycolic, 79, 80, 81.
 — hemipinic, 265.
 — hemipovinic, 265.
 — hippuric, on a new method of extracting, in considerable quantity without evaporation of the urine, and on some of its products of decomposition, by E. Riley, 97.
 — composition of, 73, 74.
 — crystalline form of, 101.
 — examination of certain products obtained from, 73.
 — preparation of, 75.
 — malic, action of a light, 65.

Acid, malic, active and passive, 63.
 — transformation of fumarate of ammonia into, 63.
 — into maleic and fumaric acids, 63.
 — metacetic, on Dr. Keller's supposed formation of, by means of flour and leather, by R. W. Forster, 28.
 — nitric, action of, on cotarnine, 266.
 — on narcotine, 261.
 — cœnanthic, on cœnanthic ether and, by W. Delffs, 279.
 — opianic, 265.
 — oxylic, 62.
 — salicylic, formation of, from anthranilic acid, by H. Gerland, 133.
 — sorbic, 283.
 — tannic, contributions towards the history of, by Dr. Strecker, 102.
 — tungstic, separation of crude into three distinct acids, 95, 96.
 Acids, on aspartic and malic, by L. Pasteur, 62.
 — organic, researches on the anhydrous, by C. Gerhardt, 127, 226.
 Air-pump, on a method of obtaining a perfect vacuum in the receiver of an, by Dr. T. Andrews, 189.
 Ales, report upon the alleged adulteration of pale, by strychnine, by Professors Graham and Hofmann, 173.
 Alizarine, 60, 61.
 Alkalies, on the compounds of cotton with the, by J. H. Gladstone, 17.
 'Amazon,' chemical report on the cause of the fire in the, by Prof. Graham, 34.
 Ammonia, apophyllate of, 267.
 — benzoglycolate of, 77.
 Amyl, on the action of ammonia on bioxy-sulphocarbonate of, by M. W. Johnson, 142.
 — on the preparation of carbonate of, by J. A. Bruce, 131.
 Amylate of sodium, action of, on palmitine, 314.

Anderson, T., on the products of the destructive distillation of animal substances, 50.

— researches on some of the crystalline constituents of opium, 257.

Aniline, monobasic citrate of, 287.

Animal substances, on the products of the destructive distillation of, by T. Anderson, 50.

Andrews, T., on a method of obtaining a perfect vacuum in the receiver of an air-pump, 189.

Ansell, G. F., on the qualitative separation of arsenic, tin and antimony, 210.

Anthropine, a new substance discovered in human fat, 85.

Antimony, on the detection and qualitative separation of tin, antimony and arsenic, by C. L. Bloxam, 104.

— on the qualitative separation of arsenic, tin and antimony, by G. F. Ansell, 210.

— organic bases containing, 66.

Apophyllates, 267.

Arsenic, on the detection and qualitative separation of tin, antimony and, by C. L. Bloxam, 104.

— on the qualitative separation of arsenic, tin and antimony, by G. F. Ansell, 210.

Atmospheric air, on the extraction of oxygen gas from, by M. Boussingault, 269.

B.

Barley, on the variation in the proportion of potash and soda present in certain samples of, grown in ground artificially impregnated with one or other of these alkalis, by Dr. Daubeny, 9.

Baryta, acid oxalate of, 223.

— apophyllate of, 267.

— benzoglycolate of, 77.

Bases, organic, containing antimony, 66.

— pyrrol, 51, 55.

Beaufoy, Henry, obituary notice of, 158.

Becquerel, E., and Frémy, E., electro-chemical researches on the properties of electrified bodies, 272.

Beef-stearine, composition of, 310.

Benzoic cuminate, or cuminic benzoate, 228.

Benzoglycolates, 76, 77, 78.

Benzoglycolic ether, 78.

Benzoic acetate, or acetic benzoate, 227.

— cinnamate, or cinnamic benzoate, 227.

— salicylate, 129.

Bertagnini, C., on the compounds of several essential, with the alkaline bisulphites, 317.

Bicarbonate of submethylum, 68.

Bichromate of diplatamine, 220.

Bioxysulphocarbonate of amyl, on the action of ammonia on, by M. W. Johnson, 142.

Bismethyl, 71.

Bisulphites, on the action of several essential oils on the alkaline, by C. Bertagnini, 317.

Bitelluride of ethyl, 72.

Bloxam, C. L., on the detection and qualitative separation of tin, antimony and arsenic, and the relation existing between these metals and others which are precipitated from their acid solutions by sulphuretted hydrogen, 104.

Bone-oil, distillation of, 50.

Boussingault, on the extraction of oxygen gas from atmospheric air, 269.

Brandy-vinegar, on the preparation of pure acetic acid from, 278.

Bristol, note on the existence of strontia in the well-waters of, by W. and T. J. Herapath, 193.

Bromide of stibethyl, 70.

Brodie, B. C., on the action of iodine on phosphorus, 289.

Bruce, J. A., on the preparation of carbonate of amyl, 131.

Buckton, G. B., observations on a new series of double chlorides containing diplatammonium, 213.

C.

Calvert, F. C., a new method for the analysis of chrome-ores, 194.

Carbonate of amyl, on the preparation of, by J. A. Bruce, 131.

Cetine, constitution of, 84.

Chemical memoranda, by R. Warington, 136.

Chemical Papers, titles of, published in British and Foreign Journals in the year 1852, 323.

Chemical Society, list of papers read at the meetings of the, from April 7, 1851, to March 15, 1852, inclusive, 160.

— proceedings at the meetings of, 29, 153, 319.

Chinese wax, on the oxidation of, by N. S. Maskelyne, 24.

Chloride, acetic, 226.

— of diplatammonium and bichloride of tin, 219.

— and chloride of copper, 218.

— and chloride of lead, 213.

Chloride of diplatosammonium and chloride of zinc, 217.

— and sesquichloride of iron, 216.

— and protochloride of mercury, 215.

— and protochloride of tin, 219.

— of platinum and narceine, 258.

— of stibethyl, 70.

— of stibmethylum, 68.

— of tellur-ethyl, 72.

Chlorides, observations on a new series of double, containing diplatosammonium, by G. B. Buckton, 213.

Chlorogenine, 58.

Chrome-ores, a new method of the analysis of chrome-ores, by F. C. Calvert, 194.

Citrate of lime, on the decomposition of, in contact with putrefying curd, by Henry How, 1.

Citrobianil, 285.

Citrobinanilate of silver, 286.

Citronanilide, 285.

Clapton, Edward, on the acid oxalates of the earths, 223.

Colorimeter, on a quick approximative method of estimating minute quantities of iron by means of a, by T. J. Herapath, 27.

Copper, benzoglycolate of, 77.

— chloride of diplatosammonium and chloride of, 218.

— method of detecting qualitatively small quantities of, in solution, 137.

Cotarnine, action of nitric acid on, 266.

Cotton, on the compound of, with the alkalies, by J. H. Gladstone, 17.

Council and officers of the Chemical Society, elected March, 30, 1852, 167.

Crystals, on the polarizing, produced by the action of iodine on the sulphate of quinine, by Dr. Herapath, 177.

Cuminic acetate or acetic cuminate, 227.

— benzoate, or benzoic cuminate, 228.

— cuminate, or anhydrous cuminic acid, 228.

D.

Daubeney, Charles, on the variation in the proportion of potash and soda in certain samples of barley, grown in plots of ground artificially impregnated with one or other of these alkalies, 9.

Delffs, W., on *œnanthic* ether and *œnanthic* acid, 279.

Density of selenium in different states, 93.

Diplatosamine, bichromate of, 220.

Diplatosammonium, chloride of, and chloride of lead, 213.

— and chloride of copper, 218.

Diplatosammonium, chloride of, and chloride of zinc, 217.

— and bichloride of tin, 219.

— and protochloride of mercury, 215.

— and protochloride of tin, 219.

— and sesquichloride of iron, 216.

— observations on a new series of double chlorides containing, by G. B. Buckton, 213.

Distillation, on the products of the destructive, of animal substances, by T. Anderson, 50.

Duffy, Patrick, on certain isomeric transformations of fats, 197.

— on the constitution of stearine, 303.

E.

Earths, on the acid oxalates of the, by Edward Clapton, 223.

Electrical conducting power of vitreous and crystalline selenium, 93.

Electro-chemical researches on the properties of electrified bodies, by E. Frémy and E. Becquerel, 272.

Ether, benzoglycolic, 79.

— *œnanthic*, on, and *œnanthic* acid, by W. Delffs, 279.

— opianic, 265.

Ether-stearic, 312.

Ethyl, observations on telluride of, by W. Mallet, 71.

— bismuthide of, 71.

— bitelluride of, 72.

Ethylates, action of the alkaline, on stearine, 311.

Ethyl-mercuric nitrate, by C. Gerhardt, 88.

F.

Fat, on the composition of human, by W. Heintz, 84.

— human, slow decomposition of, 86.

Fats, on a new method of separating, by W. Heintz, 82, 84.

— on certain isomeric transformations of, by Patrick Duffy, 197.

— various modes of testing the purity of the glycerine-, 198.

Ferric oxide, benzoglycolate of, 77.

Fire, chemical report on the cause of the, in the 'Amazon,' by Prof. Graham, 34.

Fluorine, new process for the detection of, when accompanied by silica, by G. Wilson, 151.

Forster, R. W., on Dr. Keller's supposed formation of metacetic acid by means of flour and leather, 28.

Frankland, E., contributions to the knowledge of the manufacture of gas, 39.

Frémy, E., and Becquerel, E., electrochemical researches on the properties of electrified bodies, 272.

Fumarate of ammonia, transformation of, into malic acid, 63.

G.

Gas, contributions to the knowledge of the manufacture of, by E. Frankland, 39.

Gerhardt, on ethylo-mercuric nitrate, 88.

— researches on the anhydrous organic acids, 226.

— researches on the constitution of organic acids, 127.

Gerland, H., new formation of salicylic acid, 133.

Gladstone, J. H., on the compounds of cotton with the alkalies, 17.

Glycerine, action of perchloride of phosphorus on, 315.

Glycerine-fats, various modes of testing the purity of, 198.

Glycolate of silver, 80.

— of zinc, 80.

Graham, Thomas, chemical report on the cause of the fire in the 'Amazon,' 34.

— and Hofmann, report upon the alleged adulteration of pale ales by strychnine, 173.

— and Redwood, report upon original gravities, 229.

Gravities, original, report upon, by Professors Graham, Hofman and Redwood, 229.

H.

Heintz, W., on the composition of human fat, 84.

— on a new method of separating substances possessing very similar properties, 82.

Hemipinates of potash, 265.

Hera path, Dr., on the polarizing crystals produced by the action of iodine on the sulphate of quinine, 177.

— T. J., on a quick approximative method of estimating minute quantities of iron by means of a colorimeter, 27.

— W. and T. J., note on the existence of strontia in the well-waters of Bristol, 193.

Herring-brine, on the occurrence of trimethylamine in, by A. W. Hofmann, 288.

Hittorff, on the allatropy of selenium, 90.

Hofmann, A. W., on the occurrence of trimethylamine in herring-brine, 288.

— remarks on Liebig's new method of estimating the quantity of urea in urine, 30, 23.

— and Graham, report upon the alleged adulteration of pale ales by strychnine, 173.

— and Redwood, report upon original gravities, 229.

How, Henry, on the decomposition of nitrate of lime in contact with putrefying curd, 1.

Human fat, on the composition of, by W. Heintz, 84.

— slow decomposition of, 86.

Hydrargochloride of lutidine, 54.

Hydrate of opianyl, 265.

Hydrochlorate of narceine, 258.

— of thebaine, 260.

I.

Indigo, on the valuation of, by F. Penny, 297.

Iodide of potassium, curious form of crystallization of, 136.

— of stibethyl, 70.

— of stibmethylethylum, 68.

— of stibmethylum, 68.

Iodine, on the action of, on phosphorus, by B. C. Brodie, 289.

— on the polarizing crystals produced by the action of, on sulphate of quinine, by Dr. Hera path, 177.

Iodo-quinine, optical properties of sulphate of, 178—182.

— quantitative analysis of sulphate of, 182—187.

Iron, chloride of dipotassammonium and sesquichloride of, 216.

— on a quick approximative method of estimating minute quantities of, by means of a colorimeter, by T. J. Hera path, 27.

Isomeric transformations of fats, on certain, by Patrick Duff, 197.

J.

Johnson, M. W., on the action of ammonia on kioxysulphocarbonate of amyl, 142.

L.

Lead, benzoglycolates of, 77, 78.

- Lead, chloride of diplatossammonium and chloride of, 213.
 Liebig, new method of estimating the quantity of urea in urine, 30.
 Lime, benzoglycolate of, 77.
 — on the decomposition of citrate of, in contact with putrefying curd, by Henry How, 1.
 Lutidine, 50.
 — hydrargo-chloride of, 54.

M.

- Madder-purple, 62.
 Madder-root, alteration of, by keeping, 56.
 Magnesia, benzoglycolate of, 77.
 Mallet, W., observations on tellurethyl, or telluride of ethyl, 71.
 Margarin in human fat, 85.
 Maskelyne, N. S., on the oxidation of Chinese wax, 24.
 Meetings of the Chemical Society, list of papers read at the, from April 7, 1851, to March 15, 1852, inclusive, 160.
 — proceedings at the, 29, 153, 319.
 Melting-points of fats, table of, 210.
 — of selenium, 91.
 — of stearine, 200, 205.
 Memoranda, chemical, by R. Warington, 136.
 Mercury, chloride of diplatossammonium and protochloride of, 215.
 — on a new compound of, by Sobrero and Selmi, 86.
 Methylamine, from bone-oil, 52.
 Mountain-ash, on sorbine, a new saccharine substance extracted from the berries of the, by J. Pelouze, 281.
 Mutton-stearine, composition of, 304—305.

N.

- Narceine, 258.
 Narcotine, action of nitric acid on, 261.
 Nitrate, on ethylo-mercuric, by C. Gerhardt, 88.
 — of narceine, 258.
 — of stibethyl, 69.
 — of stibemethylum, 68.
 — of tellurethyl, 72.

O.

- Obituary notice of Henry Beaufoy, Esq., 159.
 — Richard Phillips, Esq., 155.
 — William West, Esq., 158.
 Œnanthic ether and œnanthic acid, by W. Delfs, 279.

- Officers, list of, and Council, elected, March 30, 1852, 167.
 Oils, on the compounds of several essential, with the alkaline bisulphites, by C. Bertagnini, 317.
 Oleine in human fat, 85.
 Opianic ether, 265.
 Opianyl, 263.
 Opium, researches on some of the crystalline constituents of, by Dr. T. Anderson, 257.
 Organic acids, researches on the anhydrous, by C. Gerhardt, 226.
 — researches on the constitution of, by C. Gerhardt, 127.
 — bases containing antimony, 66.
 Original gravities, report upon, by Professors Graham, Hofmann and Redwood, 229.
 Oxalate, acid, of baryta, 223.
 — of strontia, 224.
 Oxalates, on the acid, of the earths, by Edward Clapton, 223.
 Oxide of tellurethyl, 72.
 Oxychloride of phosphorus, use of as a reagent in organic chemistry, 226.
 Oxygen, electrized, 274.
 — gas, on the extraction of, from atmospheric air, by M. Boussingault, 269.
 Ozone, 272, 274.

P.

- Pale ales, report upon the alleged adulteration of, by strychnine, by Professors Graham and Hofmann, 173.
 Palmitine, action of amylate of sodium on, 314.
 Papers, list of, read at the meetings of the Chemical Society, from April 7, 1851, to March 15, 1852, inclusive, 160.
 Pasteur, L., on aspartic and malic acids, 62.
 Pelouze, on sorbine, a new saccharine substance extracted from the berries of the mountain-ash, 281.
 Penny, F., on the valuation of indigo, 297.
 Pepper, J. H., on a new test for strychnine, 170.
 Perchloride of phosphorus, action of, on glycerine, 315.
 Persoz, J., on the composition of wolfram, 95.
 Phillips, Richard, obituary notice of, 155.
 Phosphide of tungsten, 94.

Phosphorus, action of perchloride of, on glycerine, 315.
 — on the action of iodine on, by B. C. Brodie, 289.
 — red, 94.
 — use of oxychloride of, as a reagent in organic chemistry, 226.
 Piria, R., on populin, 8.
 Platinochloride of thebaine, 261.
 Platinum, chloride of, and narcine, 258.
 Polarizing crystals, on the, produced by the action of iodine on the sulphate of quinine, by Dr. Herapath, 177.
 Populin, on, by R. Piria, 8.
 Potash, benzoglycolate of, 76.
 — hemipinuates of, 265.
 — on the variation in the proportion of, and soda present in certain samples of barley grown in plots of ground artificially impregnated with one or other of these alkalies, by Dr. Daubeny, 9.
 Potassium, curious form of crystallization of iodide of, 136.
 President's Report, March 30, 1852, 153.
 Proceedings at the meetings of the Chemical Society, 29, 153, 319.
 Purpurine, 62.
 Pyridine, 50.
 Pyrrol-bases, 51, 55.

Q.

Quinine, on the polarizing crystals produced by the action of iodine on the sulphate of, by Dr. Herapath, 177.

R.

Redwood, Graham and Hofmann, report upon original gravities, 229.
 Red phosphorus, 94.
 Report, chemical, on the cause of the fire in the 'Amazon,' 173.
 — President's, March 30, 1852, 153.
 — Treasurer's, 166.
 — upon the alleged adulterations of pale ales by strychnine, by Professors Graham and Hofmann, 173.
 — upon original gravities, by Professors Graham Hofmann and Redwood, 229.
 Riley, Edward, on a new method of extracting hippuric acid in considerable quantity without evaporation of the urine; and on some of its products of decomposition, 97.
 Rowney, T. H., on the occurrence of capric and caprylic acids in some fusel-oils, 22.

Rubian, action of sulphuric and muriatic acid on, 60.
 — composition of, 60.
 — on, and its products of decomposition, by E. Schunk, 56.
 — preparation of, 58.
 — properties of, 59.
 Rubianine, 61.
 Rubiretine, 60, 61.

S.

Salicylate, benzoic, 129.
 Salts of glycolic acid, 80.
 Saponification of spermaceti by caustic potash, 84.
 Schrotter's red phosphorus, 94.
 Schunck, Edward, on rubian and its products of decomposition, 56.
 Selenide of stibethyl, 70.
 Selenium, density of, in different states, 93.
 — electrical conducting power of vitreous and crystalline, 93.
 — on the allatropy of, by Dr. Hittorff, 90.
 — melting-points of, 91.
 Silver, apophyllate of, 267.
 — benzoglycolate of, 78.
 — citrobianilate of, 286.
 — glycolate of, 80.
 Silver-salt of monobasic citro-monanilic acid, 287.
 — of bibasic citro-monanilic acid, 288.
 Silica, new process for the detection of fluorine when accompanied by, 151.
 Sobrero and Selmi, on a new compound of mercury, 86.
 Socoloff and Strecker, on certain products obtained from hippuric acid, 73.
 Soda, benzoglycolate of, 77.
 — on the variation in the proportion of potash and, present in certain samples of barley grown in plots of ground, artificially impregnated with one or other of these alkalies, by Dr. Daubeny, 9.
 Sorbine, on, a new saccharine substance, extracted from the berries of the mountain-ash, by J. Pelouze, 281.
 Specific gravity of isomeric modifications of stearine, 207.
 Spermaceti, saponification of, by caustic potash, 84.
 Stearic ether, 312.
 Stearine, action of the alkaline ethylates on, 311.
 — constitution of, 84.
 — melting-points of, 200, 205.
 — on the constitution of, by P. Duffy, 303.

Stearine, specific gravity of isomeric modifications of, 207.

— various modes of purification of, by crystallisation from ether, 199.

Stearophanin in human fat, 85.

Stibamyl, 71.

Stibethyl, 69.

— bromide of, 70.

— chloride of, 70.

— iodide of, 70.

— nitrate of, 69.

— oxide of, 69.

— selenide of, 70.

— sulphate of, 69.

— sulphide of, 70.

Stibethylum, 71.

Stibmethyl, 67.

Stibmethylelium, iodide of, 68.

Stibmethylum, 67.

— bicarbonate of, 68.

— chloride of, 68.

— iodide of, 68.

— nitrate of, 68.

— oxide of, 67.

— sulphate of, 68.

Strecker, contributions towards the history of tannic acid, 102.

Strontia, acid oxalate of, 224.

— note on the existence of, in the well-waters of Bristol, by W. and T. J. Herapath, 193.

Strychnine, new test for, by J. H. Pepper, 170.

— report upon the alleged adulteration of pale ales by, by Professors Graham and Hofmann, 173.

Sublimation, modification of the ordinary process of, in a straight tube, 141.

Sulphate of narceine, 258.

— of quinine, on the polarizing crystals produced by the action of iodine on the, by Dr. Herapath, 177.

— of stibethyl, 69.

— of stibmethylum, 68.

— of thebaine, 261.

Sulphide of stibethyl, 70.

T.

Teas, additional observations on the green, of commerce, by R. Warington, 139.

Tellurethyl, chloride of, 72.

— nitrate of, 72.

— oxide of, 72.

Telluride of ethyl, observations on, by W. Mallet, 71.

Teropiammon, 261.

Thebaine, 260.

Tin, chloride of diplatossammonium and bichloride of, 219.

— and protochloride of, 219.

— on the detection and qualitative separation of tin, antimony and arsenic, by C. L. Bloxam, 104.

Treasurer's Report, March 30, 1852, 166.

Trimethylamine, on the occurrence of, in herring-brine, by A. W. Hofmann, 288.

Tungsten, phosphide of, 94.

U.

Urea, Liebig's new method of estimating the quantity of, in urine, 30.

V.

Vacuum, on a method of obtaining a perfect, in the receiver of an air-pump, 189.

Verantine, 60, 61.

Vinegar, on the preparation of pure acetic acid from wood-, and brandy-vinegar, by C. Völckel, 274.

Völckel, C., on the preparation of pure acetic acid from wood-vinegar and brandy-vinegar, 274.

W.

Warington, R., chemical memoranda, 136

Water, note on the existence of strontia in the well-waters of Bristol, by W. and T. J. Herapath, 193.

Wax, on the oxidation of Chinese, by N. S. Maskelyne, 24.

West, William, obituary notice of, 158.

White's process for the manufacture of gas, 44.

Wilson, G., on the detection of fluorine when accompanied by silica, 151.

Wöhler, on phosphide of tungsten, 94.

Wolfram, on the composition of, by J. Persoz, 95.

Wood-vinegar, preparation of pure acetic acid from, 274.

X.

Xanthine, 57, 58.

Xanthamylamide, 142, 149.

Z.

Zinc, benzoglycolate of, 77.

Zinc, chloride of diplatossammonium and chloride of, 217.

— glycolate of, 80.

END OF VOL. V.

THE
Q U A R T E R L Y
J O U R N A L
OF
THE CHEMICAL SOCIETY
OF
L O N D O N.

Committee of Publication.

B. C. BRODIE, F.R.S. THOMAS GRAHAM, F.R.S.
W. A. MILLER, M.D., F.R.S. A. W. WILLIAMSON, PH.D.

VOL. VI.

L O N D O N :
HIPPOLYTE BAILLIERE, 219, REGENT STREET,
AND 290, BROADWAY, NEW YORK, U.S.

PARIS: J. B. BAILLIERE, RUE HAUTEFEUILLE.

MADRID: BAILLY BAILLIERE, CALLE DEL PRINCIPE.

1854.

LONDON :

Printed by Schulze and Co., 13, Poland Street.

CONTENTS

OF

THE SIXTH VOLUME.

	PAGE
On some Compounds of Urea, and on a New Method for the Determination of Chloride of Sodium and of Urea in Urine. By Justus Liebig	1
On the mode of estimating the value of Red Prussiate of Potash. By Francis Lieshing	31
On an Improved Assay Balance. By George H. Makins	36
On some New Compounds of Tellurethyl. By Professor Wöhler	40
Description of an Apparatus for Collecting Gases over Water or Mercury. By W. M. Williams	44
On the Law of Electrolysis. By Professor H. Buff	47
Analytical Notes. By A. B. Northcote and A. H. Church	53
Proceedings at the Meetings of the Chemical Society	54
Notices of Papers contained in other Journals :	
On a New Series of Organic Bodies containing Metals By Dr. E. Frankland	57
On Meconic Acid and its Derivatives. By Henry How	72
On some Salts and Decomposition-Products of Pyromeconic Acid. By James Brown	78
Researches on Chemical Affinity. First Memoir. By R. Bunsen	82
On the Constitution of Iodide of Nitrogen. By R. Bunsen	90
On the Solid Compound obtained by Distilling Stearic Acid with Lime. By T. H. Rowney, Ph.D., F.C.S.	97
On Deposits of Soluble or Gelatinous Silica in the Lower Beds of the Chalk Formation. By J. T. Way	102
On a Compound Sulphate of Potash and Soda. By J. H. Gladstone, Ph.D., F.R.S., F.C.S.	106
Note on Thierschite. By J. Liebig	112
On Kyanurenic Acid. By J. Liebig	113
Analysis of the Waters from the Deep Wells of Westbourne Park, and Russell Square, and the Artesian Well of the Hanwell Lunatic Asylum. By C. H. Clarke, Esq. B.A., F.S.A., and H. Medlock, Esq., F.C.S.	115
On the Increase in Weight of Molasses Casks, which occasionally arises from absorption. By W. Ferguson, Esq., F.C.S.	122
On some New Basic Products obtained by the Decomposition of Vegetable Alkaloids. By H. How, Esq. F.C.S.	125

	PAGE
Note on Sulphantimoniate of Copper and Zinc, by Professor Ettling	140
Proceedings at the Meetings of the Chemical Society	141
Annual General Meeting	147
President's Address	150
Notices of Papers contained in other Journals :	
On the general distribution of Iodine. By Stevenson Macadam	166
On a new Oxide of Hydrogen, and its relation to Ozone. By M. Baumert	169
On Piperidine, a new Alkali derived from Piperine. By A. Cahours	175
Researches on the Oxygen-Radicals. By L. Chiozza	182
On Anhydrous Organic Acids. By L. Chiozza	184
On Sinapine. By MM. Babo and Hirschbrunn	187
On the Amides. By C. Gerhardt	193
On an Improved Apparatus for the Analysis of Gases. By Dr. E. Frankland, F.R.S., and W. J. Ward, Esq.	197
On the use of Hydrogen in determining Vapour-Densities, and on the Acidification of Alcohols by Oxygen-gas or Atmospheric Air. By Robert Railton, of University College	205
On the use of Gas as Fuel in Organic Analysis. By A. W. Hofmann, Ph.D., F.R.S.	209
On the Acetates and other Compounds of Alumina. By Walter Crum, F.R.S.	217
Notices of Papers contained in other Journals :	
Researches on the Quantities of Heat disengaged in Chemical and Molecular Actions. By P. A. Favre and J. T. Silbermann	235
Researches on Didymium and its Principal Compounds. By C. Maignac	260
Researches on the Cinchona Alkaloids. By L. Pasteur	273
Transformation of the two kinds of Tartaric Acid into Racemic Acid. Discovery of Inactive Tartaric Acid. New Method of separating Racemic Acid into the two Tartaric Acids, Right and Left. By L. Pasteur	277
On the Compounds of Glycerine with Acids, and on the Synthesis of the proximate principles of Animal Fats. By M. Berthelot	280
On Propionic Alcohol. By G. Chancel	287
On two New Methods for the Determination of Nitrogen in Organic and Inorganic Compounds. By Maxwell Simpson, M.D., Dublin, F.C.S.	289
On Ethers intermediate between the Enanthylic and the Methylic, Ethylic, and Amylic Series, and on the constitution of Castor-oil Alcohol. By A. W. Wills, of University College, London	307
Proceedings at the Meetings of the Chemical Society	317
Titles of Chemical Papers contained in British and Foreign Journals	321
Index	373

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

I.—*On some Compounds of Urea, and on a New Method for the Determination of Chloride of Sodium and of Urea in Urine.*

BY JUSTUS LIEBIG.*

In the number of the Annals of Chemistry and Pharmacy for October, 1851, I have mentioned a compound of urea with protoxide of mercury, which is obtained in the form of a white gelatinous precipitate when a solution of protochloride of mercury (corrosive sublimate) is poured into a solution of urea, previously made alkaline by potassa.

Werther had already previously observed, that urea forms with protochloride of mercury a compound, crystallizing in flat prisms of a pearly lustre, which yields, according to Piria, a white precipitate with potassa, resembling the amide of mercury, and exploding when heated.

I have obtained three compounds of urea with protoxide of mercury; one of which is formed in a direct manner, and was described by Dessaignes a few weeks after the publication of my notice quoted above; the other two are obtained by precipitating an alkaline solution of urea with corrosive sublimate or nitrate of protoxide of mercury.

* The substance of this paper was communicated to the Society on the 10th of January, 1852 (See this Journal, Vol. V, p. 30).

*A. Urea and Protoxide of Mercury, $2\text{HgO} + \text{U}^+$.**—On adding to a warm solution of urea protoxide of mercury suspended in water, the first portions are, as described by Dessaignes, completely dissolved in the liquor; an excess of protoxide of mercury is gradually changed into a white or yellowish-white powder. When dried *in vacuo*, the colour of this compound is slightly yellow; when heated in a tube, whilst dry, it is decomposed, without explosion; ammonia is given off, metallic mercury sublimes, and a yellow residue of mellon remains, which disappears only on ignition, when cyanogen gas is disengaged. In the moist state it decrepitates under the same circumstances; in the dark, sparks of a green light are observed.

By digesting protoxide of mercury in the water-bath with a solution of urea, I have in no instance succeeded in obtaining this compound entirely free from cyanate of protoxide or suboxide of mercury; a feeble, but very distinct disengagement of ammonia invariably takes place. The yellowish-white powder formed dissolves in this case, in hydrocyanic and hydrochloric acids, leaving a black residue of metallic mercury behind, and disengaging a small quantity of gas; the solution, when treated with milk of lime, gives off ammonia. This is the character of the cyanates. When digested in the water-bath for a longer period, the urea-compound loses its yellowish-white colour, and becomes lemon-coloured and granular. This latter compound exhibits the deportment of a basic cyanate of mercury.

2.000 grms., dissolved in hydrocyanic acid, gave on evaporation a dry residue of urea and cyanide of mercury weighing 2.394 grms., from which were obtained by precipitation with sulphuretted hydrogen 1.745 of sulphide of mercury, and by evaporation of the filtrate, 0.429 grm. of urea. This gives for

100 Urea and protoxide of mercury	{ Protoxide of mercury	81.09
	{ Urea	21.45
		102.54

The increase in weight, amounting to upwards of $2\frac{1}{2}$ per cent, appears to confirm the formula of Dessaignes, according to which 1 equiv. of water separates by the entrance of protoxide of mercury into this compound. The urea obtained by me was not however perfectly dry; it remained somewhat pasty, and possessed, feebly, the

* $\text{U}^+ = 1$ equiv. of urea.

reactions of sulphocyanide of ammonium. I am therefore not quite sure about the fact of water separating from the urea, inasmuch as in the silver-compound which contains 3 equivs. of oxide of silver, a similar replacement of water by oxide of silver does not occur.

By the same process of digesting a solution containing about 10 per cent of urea with protoxide of mercury until the reddish-yellow colour of the oxide was completely converted into a yellowish-white, I have, in several instances, obtained a urea-compound containing 3 equivs. of protoxide, instead of 2, just as the compound to be described forthwith.

B. Urea and Protoxide of Mercury, 3 HgO + U.—On adding solution of potassa to a solution of urea, and mixing with it a solution of corrosive sublimate, the liquid being continually kept alkaline by renewed addition of solution of potassa, a thick, gelatinous, snow-white precipitate is obtained, which, when brought into boiling water whilst still moist, after being first completely washed, is converted into a sandy, granular powder of yellow or yellowish-white colour. The water is hereby rendered alkaline, and takes up a certain amount of urea.

When dried, the powder is reddish-yellow; on being heated in a narrow glass tube, it is decomposed with decrepitation, and when moist, frequently with explosion; in the dark, the substance becomes luminous during this decomposition, and beautiful green sparks are observed; water and carbonate of ammonia are hereby given off, and metallic mercury sublimes, mostly without any residue of mellon; the compound dissolves in hydrocyanic and hydrochloric acids without effervescence; alkalis produce in the latter solution a yellowish-white precipitate.

The analysis of this compound from different preparations yielded the following results:

I. 4.606 grms. of substance, dried *in vacuo* over sulphuric acid, gave 4.152 of sulphide of mercury.

II. 2.685 grms. of substance, dried *in vacuo* over sulphuric acid, gave 2.436 of sulphide of mercury.

III. 2.1904 grms. of substance, dried *in vacuo* over sulphuric acid, gave 1.9605 of sulphide of mercury.

IV. 1.7578 grms. of substance, dried *in vacuo* over sulphuric acid, gave 1.5815 of sulphide of mercury.

V. 1.000 grms. of substance, by combustion with oxide of copper, gave 0.1144 of carbonic acid and 0.0594 of water.

VI. 2.094 grms. yielded by direct determination 0.350 grms. of urea.

Composition in 100 parts :

	Calculated.		I.	II.	III.	IV.	V.	VI.
Protoxide of mercury . .	324	84.37	84.1	84.3	83.91	84	—	—
Urea	60	15.63					15.6	16.6
	384	100.00						

C. Urea and Protoxide of Mercury, $4 \text{ HgO} + \overset{+}{\text{U}}$.—On precipitating a solution of nitrate of protoxide of mercury, instead of a solution of corrosive sublimate, with an alkaline solution of urea, a white, somewhat less gelatinous precipitate is obtained, which also loses this state in boiling water, and becomes a sandy powder. No distinct crystalline structure was observed under the microscope in either of these compounds.

The properties of this compound do not differ from those of the others previously described; it contains, however, more protoxide of mercury. The substance from different preparations, dried over sulphuric acid, yielded by analysis the following results :

I. 0.987 grms. gave $0.932 = 94.4$ per cent. of sulphide of mercury.

II. 2.200 grms. gave $2.085 = 94.3$ per cent of sulphide of mercury and $0.279 = 12.7$ per cent of urea.

III. 3.000 grms. gave 2.860 of sulphide of mercury $= 95.3$ per cent and $0.329 = 10.96$ of urea.

IV. 2.000 grms. gave $1.880 = 94$ per cent of sulphide of mercury; these numbers correspond to the following composition :

	Calculated.		Found.			
			I.	II.	III.	IV.
4 equivs. of protoxide of mercury . .	432	87.804	87.82	87.3	88.72	87.4
1 „ of urea	60	12.196	—	12.7	10.96	—
	492	100.000		100.0		

Urea and Protoxide of Silver.—When freshly precipitated oxide of silver in the moist state is put into a solution of urea, and the liquid left in a warm place of from 40° to 50° , the oxide of silver changes its colour after one or two hours, appears to swell up from one point, and becomes granular and of a lighter grey colour; when the mass has assumed a uniform colour, and some of it is examined under the microscope, the powder is found to consist of transparent, pretty regular, scarcely coloured, prismatic crystals. The compound is readily soluble in nitric acid without disengagement of gas, but with

difficulty in ammonia; when touched at one point with an ignited body, it undergoes a tinderlike combustion, a large quantity of ammonia being disengaged, and is converted into a darker coloured coherent mass, which now effervesces with acids and evolves with nitric acid, besides carbonic acid, nitric oxide, or nitrous acid. On heating the burned mass in a tube, a strong smell of cyanic acid is perceived, and a white body sublimes possessing the properties of cyanide. The urea-compound is converted by the first combustion into a mixture of metallic silver and cyanate of suboxide of silver. On being heated in a tube, a second incandescence takes place; the cyanate of suboxide of silver is decomposed; part of the cyanogen escapes in form of cyanic acid; and another portion remains with the silver; in fact, when the residue is boiled with dilute nitric acid, a mixture of white cyanide of silver and brown paracyanide of silver is left behind.

By analysing the compound, from different preparations, there was obtained:

I. From 2.0340 grms. of urea-oxide of silver, dried *in vacuo* over sulphuric acid, 0.2960 grms. of pure urea = 14.25 per cent.

II. From 1.052 of the compound 0.826 of metallic silver.

III.	„	1.585	„	„	1.248	„	„
IV.	„	1.517	„	„	1.222	„	„
V.	„	1.758	„	„	1.385	„	„
VI.	„	1.939	„	„	1.529	„	„
VII.	„	1.574	„	„	1.242	„	„

These results lead to the following composition:

	Calculated.		I.	II.	III.	IV.	V.	VI.	VII.
3 eqs. of oxide of silver	348	85.29	—	84.32	84.54	84.81	83.50	84.68	84.75
1 eq. of urea	60	14.71	14.25	—	—	—	—	—	—
	408	100.00							

Nitrate of Urea and Protoxide of Mercury.—On adding a solution of nitrate of protoxide of mercury to a solution of urea, a snow-white, flocculent precipitate is immediately formed, containing urea, protoxide of mercury and nitric acid. According to the proportion in which the two solutions are mixed, or according to the amount of acid in the mercury-salt, three compounds or mixtures of them are formed, differing by their amount of protoxide of mercury.

These various compounds possess the following properties in common: they yield, when burned with oxide of copper, a mixture of gases containing nitrogen and carbonic acid, in the proportion of

3 to 2 volumes; this is the same proportion as that in nitrate of urea. On removing the protoxide of mercury by means of sulphuretted hydrogen, pure nitrate of urea remains in the liquor filtered off, which crystallizes to the last drop. These compounds differ, therefore, only by their unequal amount of protoxide of mercury; they dissolve in hydrocyanic and hot nitric acid without leaving a residue: potassa produces a white precipitate in the nitric solution. Heated for some time, when dry, in a current of warm air, decomposition ensues; they assume a yellowish colour, and their nitric solution yields now a yellowish precipitate with potassa.

A. $\text{NO}_5, \overset{+}{\text{U}} + 4 \text{HgO}$.—When the solution of urea is mixed with the mercurial solution in a *very dilute* and warm state, and the precipitate formed is digested with the liquor, it quickly aggregates to a heavy white powder, which presents under the microscope the form of roundish grains, consisting of very small, concentrically grouped needles. In the dry state this powder rolls on paper like fine sand. After being dried *in vacuo*, there was obtained by solution in hydrocyanic acid and precipitation with sulphuretted hydrogen from :

I. 1.990 grms. of the substance, 1.680 sulphide of mercury = 88.4 per cent.

II. 2.000 grms. of the substance, 1.700 sulphide of mercury = 85. per cent.

III. 2.000 gave, after the removal of the mercury, 0.410 of nitrate of urea, and after its saturation with carbonate of baryta 0.681 nitrate of baryta and urea. On treating this 0.681 grm. with alcohol, 0.462 of nitrate of baryta was left.

This compound accordingly consists of :

	Calculated.		I.	II.	III.
	54	9.90			
1 equiv. nitric acid. . . .	60	10.98	—	—	9.55
1 „ urea.	432	79.12	78.58	79.14	10.95
4 „ protoxide of mercury					—
	546	100.00			

B. $\text{NO}_5, \overset{+}{\text{U}} + 2 \text{HgO}$.—On adding a solution of crystallized nitrate of urea to a moderately dilute solution of nitrate of protoxide of mercury, mixed with some nitric acid, until a slight cloudiness ensues which does not disappear again, then filtering and allowing the mixture to stand quietly, solid hard crystalline crusts are deposited over night, consisting of an aggregate of small, rectangular, brilliant,

transparent tablets. By treatment with boiling water, these crystals are decomposed; they become dim and opaque, and are transformed into the compound just described, the water removing from them nitrate of urea. The analysis yielded the following results:

- I. 2.400 grms. gave 1.696 sulphide of mercury.
 II. 2.000 „ „ 1.414 „ „ „
 III. 2.000 „ „ 0.700 grm. nitrate of urea, from which were obtained 0.780 nitrate of baryta.

This compound therefore consists of:

	Calculated.		I.	II.	III.
1 equiv. nitric acid	54	16.37	—	—	16.1
1 „ urea	60	18.18	—	—	18.9
2 „ protoxide of mercury	216	65.45	65.6	65.7	—
	330	100.00			

C. $\text{NO}_5, \text{U}^+ + 3 \text{HgO}$.—On adding a dilute solution of nitrate of protoxide of mercury to a solution of urea, as long as a precipitate is formed, and allowing the white mass to stand in a warm place of from 40° to 50° , the precipitate is converted into six-sided transparent tablets, amongst which are observed under the microscope, roundish grains of the first, and isolated square tablets of the second compound. In no instance have I succeeded in obtaining this compound quite pure and free from those admixtures; the microscope however plainly indicates that we have before us a compound totally different from the other two.

2.000 grms. gave 1.550 sulphide of mercury, 0.864 nitrate of baryta and urea, and from this 0.597 nitrate of baryta.

3.000 grms. gave 2.488 sulphide of mercury, 1.256 nitrate of baryta and urea, and 0.836 nitrate of baryta.

The first analysis yields for 100 substance, 77.5 sulphide of mercury; the second, 80.3. Assuming the compound to contain 3 equivs. of protoxide of mercury for 1 equiv. of nitrate of urea, 79.4 per cent of sulphide of mercury should be obtained from it, when in a pure state.

QUANTITATIVE DETERMINATION OF CHLORINE IN NEUTRAL LIQUIDS BY MEANS OF PROTOXIDE OF MERCURY.

Nitrate of protoxide of mercury added to a solution of urea, immediately produces a thick white precipitate; this precipitation does not take place with solution of corrosive sublimate.

On mixing a chlorine-compound of the alkali-metals with nitrate of

protoxide of mercury, a mutual transposition into sublimate and nitrate of the alkaline base takes place. A saturated solution of chloride of sodium, mixed with a concentrated solution of nitrate of protoxide of mercury, solidifies into a foliated mass of crystals of protochloride of mercury.

On mixing a solution of urea with chloride of sodium, and adding gradually, in small portions, a dilute solution of nitrate of protoxide of mercury, a white cloudiness ensues at the place where both liquids meet, disappearing, however, immediately on shaking, leaving the liquor as bright and transparent as before; without the chloride of sodium, it would have retained its cloudiness. This deportment lasts until the nitrate of protoxide of mercury added, exactly suffices to transform the chloride of sodium into corrosive sublimate; beyond this limit, a single drop of the mercurial salt produces a lasting white cloudiness.

From this deportment it is evident that, if we know the amount of mercury in the solution of nitrate of protoxide of mercury which has been added to a solution of urea, containing an unknown quantity of chloride of sodium, until a permanent precipitate is formed, we also know the amount of chlorine or of chloride of sodium in this solution; 1 equiv. of mercury in the mercurial solution used, corresponds exactly to 1 equiv. of chlorine (or chloride of sodium).

If, on the contrary, the amount of chloride of sodium in the solution of urea be known, and the amount of mercury in the mercurial solution be unknown, the latter amount may be calculated with facility.

This method of determining the amount of chloride of sodium is particularly applicable in the case of urine, inasmuch as no urea requires to be added; as a matter of course, it may also be used with advantage for the estimation of the chlorine in brine or sea-water, and, generally speaking, in every case when a large number of such determinations are to be made in the shortest possible time. In those cases in which the chloride of sodium is not to be estimated in urine, but in other neutral liquids, the method, now to be described, has to be modified in some points.

Preparation of the Nitrate of Protoxide of Mercury.—If chemically pure mercury be at our disposal, this preparation does not offer any difficulty. 5 parts of nitric acid of 1.425 spec. grav. are poured on 1 part of mercury in a beaker; this is then placed over a water-bath, and heated, with frequent additions of a few drops of nitric acid, until no more red vapours escape, and a drop of it mixed with solution of chloride of sodium ceases to produce a cloudi-

ness; the solution is then evaporated in the same vessel, and over the water-bath, to the consistence of a syrup. The mercury of commerce cannot be used for this purpose, because it always contains lead and bismuth, which render the determination of chlorine uncertain. The presence of lead or bismuth immediately produces a white cloudiness, or an opalescence, on mixing the mercurial solution with a solution of chloride of sodium containing urea, which renders it difficult to recognise clearly the limit—or the point when the urea-compound of the nitrate of protoxide of mercury is precipitated. It becomes, therefore, necessary first to obtain a crystallization of nitrate of suboxide of mercury by boiling dilute nitric acid with an excess of metallic mercury, concentrating and cooling. The crystals of this salt are then separated from the mother-liquor containing the other metals, washed first with some dilute nitric acid and then with water, whereby part of the salt may be transformed into a basic salt; they are next dissolved in nitric acid, and heated until no further escape of nitric acid takes place, and a drop of it tested by chloride of sodium is no longer precipitated. The solution of the salt of the protoxide is now evaporated in a water-bath, to the consistence of a syrup, and diluted with 10 times its bulk of water. Should there be, after 24 hours, a separation of basic salt of the protoxide from the mixture, it must be filtered off.

In order to employ this mercurial solution for the determination of chloride of sodium, it must be graduated—that is to say, reduced to a definite amount of protoxide. This may be effected in two ways: it is either graduated in a direct manner with a solution of pure chloride of sodium of a definite strength; or the amount of protoxide of mercury is estimated, and the solution then diluted with such a quantity of water, that a cubic centimeter of the dilute solution indicates exactly 10 milligrammes of chloride of sodium. Both methods require a solution of chloride of sodium of a definite strength.

When pure transparent rock-salt, in coarse pieces, is digested with water during twenty-four hours, at a temperature of from 12° to 24° , and the liquor frequently shaken during that time, an unvarying quantity of the salt is dissolved.

10 cub. cent. of the clear filtered solution contain a definite, invariable weight of chloride of sodium; a determination by the balance is hereby not required.

100 parts of water dissolve, according to the experiments of Fuchs, 36; according to the latest investigations of Fehling, 35.91; and

10 parts by weight of the solution contain 2·6423 of chloride of sodium. The spec. grav. of the solution is, according to Karsten, 1·2046; according to Anthon, 1·205; 10 cub. cent. of a saturated solution should consequently contain 3·183 grms. of chloride of sodium.

By evaporating 10 cub. cent. of saturated solution of chloride of sodium, I have obtained 3·185, 3·184, 3·195, 3·175, mean 3·184 grms. of chloride of sodium. This is the number obtained by Fuchs and Fehling.

If, therefore, 20 cub. cent. of solution of chloride of sodium, saturated at the ordinary temperature, be exactly measured by means of a pipette (the drop adhering to the end of the pipette not blown off), and mixed with 298·4 cub. cent. of water, we have :

298·4 cub. cent. of water	}	318·4 cub. cent.
20·0 ,, ,, solution of chloride of sodium		

of dilute solution of chloride of sodium containing 2×3184 milligrammes of this salt. 10 cub. cent. of this solution contain, therefore, 200 milligrammes of chloride of sodium.

Preparation of the test-liquor for the determination of Chloride of Sodium.—In a small pipette, holding exactly 10 cub. cent. of liquor when filled to a certain line in the narrow tube, 10 cub. cent. of the solution of chloride of sodium, just described, are measured off, and put into a small beaker; to this are added 3 cub. cent. of a solution of urea, containing in 100 cub. cent. 4 grms. or in 1 cub. cent. 40 milligrammes of urea.*

The dilute solution of mercury, to be graduated, is now put into a burette, the height of the liquor noted, and added drop by drop to the solution of chloride of sodium mixed with urea, whilst the liquor is kept in a rotatory motion. The test is finished as soon as a distinct precipitate is permanently formed in the liquor.†

If for 10 cub. cent. of solution of chloride of sodium 7·8 cub. cent. of the mercurial solution have been required to induce the precipitate, the latter is too concentrated to admit of an exact graduation;

* For the purpose of measuring this solution, a small measure is made of a narrow test-tube, in which 3 cub. cent. of liquor are measured off; the height of the liquor is marked by a scratch with a file; a few drops more or less are of no consequence.

† An opalescence of the liquor is not to be regarded; it is caused by a trace of foreign metals; it may immediately be recognised as not pertaining to the test, when, after its appearance, the cloudiness of the liquor is not increased by the addition of a few drops of the mercurial solution. This is not the case when the cloudiness has been caused by the urea-compound; every additional drop of the mercurial solution then produces a cloud, by which the liquor is rendered more opaque than it was before.

it has then to be diluted with its bulk of water, and the test to be made a second time. Suppose 15.5 cub. cent. of the mercurial solution have now been required to produce a cloudiness in 10 cub. cent. of the solution of chloride of sodium mixed with urea; then to 155 volumes of this mercurial solution, 45 volumes of water must be added, whereby 200 volumes of a solution are produced, of which 20 cub. cent. indicate exactly 200 milligrammes of chloride of sodium, or 1 cub. cent. 10 milligrammes.

If in the first trial 2.7 cub. cent. of mercurial solution be required for 10 cub. cent. of the solution of chloride of sodium, 5 or 6 times its bulk of water must be added before the first graduation is made. In short, the mercurial solution to be graduated should not be too far removed in concentration from the amount which it is ultimately to contain.

The correctness of the measurements is finally controlled by a special experiment; the degree of cloudiness, permanently obtained on mixing 20 cub. cent. of the test-liquor with 10 cub. cent. of the solution of common salt with urea, must be kept in view when making the real estimations. In these quantitative determinations of chloride of sodium, a source of error easily avoided, however, by a little practice, exists in using too much mercurial solution, whereby the cloudiness is increased, or too little, whereby it is diminished.

The test-liquor, the preparation of which I have just described, is calculated for those cases in which no other salts, besides chloride, and no excess of urea exist in the solution; it leads, however, to a slight error, when employed for determining the chloride of sodium in urine, inasmuch as it indicates a smaller amount in urine than really exists therein. This error is occasioned by the cloudiness, the index of the termination of the experiment, appearing somewhat earlier in the presence of much urea and other salts than without, inasmuch as the precipitate is less soluble in such liquids. A deposit of nitrate of urea and protoxide of mercury is, as a matter of course, not produced until the liquor is saturated with it; the mercurial solution always contains free nitric acid, which dissolves more of it than water, and this again more than a nitric solution of urea.

Since then urine generally contains more urea than has been added to the solution of chloride of sodium when graduating the mercurial solution, and this urea seizes part of the free nitric acid of the mercurial salt, forming nitrate of urea, the solvent power of the liquor for the precipitate is diminished, and the precipitate appears somewhat sooner—that is, somewhat less of the test-liquor is required to produce the cloudiness. This error is completely obviated by adding

5 cub. cent. of a cold saturated solution of sulphate of soda to the 10 cub. cent. of solution of chloride of sodium, mixed with 3 cub. cent. of solution of urea, and then graduating the test-liquor.

Nitrate of protoxide of mercury produces, with a solution of sulphate of soda, a yellow pulverulent precipitate of *turpethum minerale*. If the sulphate of soda contains chloride of sodium, the precipitate of turpethum, on addition of nitrate of protoxide of mercury, is not formed until the chloride of sodium is converted into sublimate; the addition of sulphate of soda alters, therefore, the experiment only in this manner, that the free acid of the mercurial salt combines with the sulphate of soda to form an acid salt, whereby the same effect is produced as by an excess of urea.

On adding urea and then nitrate of protoxide of mercury to a solution of sulphate of soda, free from chloride of sodium, the liquor coagulates, even when tolerably dilute, to a gelatinous mass of a snow-white compound, containing sulphuric acid, urea, and protoxide of mercury; it is somewhat less soluble in water and sulphuric acid than the corresponding nitrate.

The method of determining chlorine by means of a silver-salt is so exact that no more exact process could be said to exist; but the method of estimation with nitrate of protoxide of mercury, just described, is not inferior to that with nitrate of silver, as regards precision; it is applicable, however, only to neutral, or very slightly acid, or alkaline liquids, because an excess of acid prevents the precipitation of the urea-compound.

The following numbers enable us to make a comparison of both methods; they refer to very dilute solutions of chloride of sodium, presenting but very slight difference in the amount of chloride of sodium.

Amount in 10 cub. cent. of the solution.		Estimated by nitrate of protoxide of mercury.	
I.	81·5 milligrammes	81·6	
II.	80·2 „	79·8	
III.	82·7 „	82·3	

We observe readily that these numbers do not differ from each other in a greater degree, than in the case of determinations made with standard solutions of nitrate of silver in the usual way.

The only advantage the nitrate of the protoxide of mercury has over the silver-salts consists, as I believe, in the circumstance, that the termination of the experiment is indicated by the commencement of the reaction. In using nitrate of silver the experiment is finished, when no farther precipitate is perceptible; in this case the cloudi-

ness of the liquor, the difficulty to render it clear in order to observe the end of the experiment, impedes the dispatch of the execution. In using the mercury-salt, some dozen analyses may be made in an hour; hence, this method is particularly applicable to technical purposes, for the estimation of chloride of sodium in Glauber's salt, and, after previous neutralization, in the soda of commerce.

In order to determine the chloride of sodium in urine, it is necessary to remove previously the phosphoric acid contained in it. I have found a mixture of 1 volume of a cold saturated solution of nitrate of baryta, and 2 volumes of cold saturated baryta-water, to answer this purpose very well. To 2 volumes of the urine to be examined, 1 volume of this mixture is added, and the precipitate formed filtered off; the liquor is alkaline from the excess of baryta; this alkaline reaction must be removed by means of nitric acid.

For the experiment, 15 cub. cent. of this liquor are taken, corresponding to 10 cub. cent. of urine; and for the measuring of it a small pipette is used, holding exactly this volume, when filled to the line, without subdivision. The liquor is put into a small beaker-glass (the last drop adhering to the pipette not blown or taken off), and mixed with the mercury-solution whilst it is continually being stirred. When cloudiness ensues, the quantity of test-liquor used is read off from the burette. Every cub. cent. used corresponds to 10 milligrammes of chloride of sodium.

By this method, I have made a large number of comparative experiments, with a solution of silver also graduated for 10 milligrammes of chloride of sodium in 1 cub. cent. of water; and the following numbers may furnish a specimen of the precision of the first, and of its close approximation to the ordinary method:

				By means of nitrate of:	
				silver.	protoxide of mercury.
				Milligrms.	Milligrms.
1.	10	cub. cent. of morning urine contained	.	115.4	115.0
2.	10	" " " " " of a child	.	110.	110.
3.	10	" " " of urine secreted after dinner	.	164.	164.
4.	10	" " " " before dinner	.	189.	188.5
5.	10	" " " " " " "	.	74.	74.
6.	10	" " " " " " "	.	142.8	142.
7.	10	" " " " after taking tea	.	127.5	127.5
8.	10	" " " " " " beer.	.	27.7	27.7
9.	10	" " " " { before bed-time, after taking beer	.	25.	25.
10.	10	" " " of the same urine	.	25.	25.
11.	10	" " " of urine (woman)	.	110.	110.
12.	10	" " " of the same urine	.	110.	110.

Chloride of sodium.

The correctness and accordance of these determinations depends chiefly upon this point, that, in neutralizing the urine mixed with the baryta and nitrate of baryta, no more nitric acid is added than is just required in order to produce a feebly acid reaction. For this reason it is preferable to acidulate with nitric acid the whole filtrate, of which a small portion is kept back, and not the 15 cub. cent. measured off for the test; one drop too much is of no consequence in 100 or more cub. cent. of liquor, whilst if added to the small portion for the test, it would interfere with the precision of the experiment.

In determining urea in urine, the amount of ehloride of sodium in it causes an error, which, for very accurate analyses, is obviated by previously removing the chlorine; and in this case the determination of the chloride of sodium, by means of nitrate of mercury, serves to indicate the exact amount of silver-solution graduated for the same quantity of chloride of sodium, which is to be added to the urine without further experimenting.

DETERMINATION OF PROTOXIDE OF MERCURY IN A SOLUTION OF NITRATE OF MERCURY.

On mixing solutions of nitrate of protoxide of mercury and phosphate of soda, a white flocculent precipitate of phosphate of protoxide of mercury is immediately formed, which, on being left in the liquor, rapidly becomes crystalline.

Solution of corrosive sublimate, however, may be mixed with the alkaline phosphate without producing a precipitate.

On adding solution of chloride of sodium to the mixture of the two former salts, before the precipitate becomes crystalline, the phosphate of protoxide of mercury formed immediately decomposes with the chloride of sodium, into sublimate and phosphate of soda; the precipitate formed disappears, and the liquor becomes clear and bright.

On this deportment I have based a method of determining the amount of protoxide of mercury in its nitric solution with tolerable precision. 1 equiv. of phosphate of protoxide of mercury requires to redissolve it 1 equiv. of chloride of sodium; if, therefore, the amount of ehloride of sodium added be known, the amount of mercury in the mercurial solution is also known.

Since the equivalent of chloride of sodium is almost one half of that of protoxide of mercury, this method is not so precise and accurate as the determination of ehloride of sodium by means of the mercury-salt; inasmuch as a small error in the addition of the solution of chloride of sodium causes one which is twice as great in

the calculation of the mercury. For certain purposes, however, especially for those which I have in view, this method is sufficiently exact.

Preparation of the normal solution of Chloride of Sodium to be employed for determining the Mercury.—According to the equivalents of chloride of sodium and of the protoxide of mercury, 108 protoxide of mercury correspond to 58·6 chloride of sodium, or 200 of oxide correspond to 108·52 of the salt.

If, therefore, 20 c. c. of a saturated solution of chloride of sodium be mixed with 566·8 c. c. of water, we have 586·8 c. c. of a dilute solution of chloride of sodium, containing in the whole 6368 milligrammes of chloride of sodium (viz. the amount contained in 20 cub. cent. of the saturated solution); in 10 cub. cent. there are, therefore, 108·52 milligrammes of chloride of sodium, corresponding to 200 milligrammes of protoxide of mercury (1 cub. cent. of solution of chloride of sodium = 20 milligrammes of protoxide of mercury).

In order to determine with some accuracy the amount of oxide in a solution of nitrate of protoxide of mercury by means of this method, the solution should not be too concentrated, partly for the sake of measuring exactly, and partly on account of the limits of the reaction being more easily perceived in dilute liquors than in concentrated ones; it is desirable that the mercurial solution should not contain more than from 180 to 200 milligrammes of protoxide of mercury in 10 cub. cent.

In order to determine the concentration, the following preliminary experiment is made:—10 cub. cent. of the solution of chloride of sodium are mixed with 4 cub. cent. of a cold saturated solution of phosphate of soda (the officinal salt), and to this mixture the mercurial solution is poured from a burette, until, on shaking, the precipitate does not any longer disappear. Suppose 2·4 cub. cent. of mercurial solution had been used, they would then contain 200 milligrammes of oxide. This is too concentrated; 1 cub. cent. of it contains upwards of 80 milligrammes of oxide, but the exact determination requires that 1 cub. cent. should not contain more than 20 milligrammes. This solution should therefore be diluted with 3 volumes of water before the actual experiment is made.

Of this dilute solution of mercury, 10 cub. cent. are now put into a beaker, mixed with 4 cub. cent. of the above-mentioned solution of phosphate of soda, and the graduated solution of chloride of sodium added from the burette; the solution is kept in constant motion, and the test added very slowly towards the end, until the white precipitate formed is completely redissolved.

The addition of the solutions of phosphate of soda and of chloride of sodium must follow in rapid succession: if but a few minutes

elapse between the two additions, the phosphate of protoxide of mercury becomes crystalline, and does no longer dissolve, or at least with difficulty. Moreover, the solution of mercury must not contain too much free acid; it contains the proper amount, if, after the addition of the phosphate of soda, the mixture does not exhibit an acid reaction. If it has an acid reaction, it must previously be mixed with a few drops of carbonate of soda, until a basic salt is precipitated, which is redissolved by means of one or two drops of nitric acid.

It is a special character of this method that its errors depend chiefly on the circumstance of one or more drops of solution of chloride of sodium being added in excess, in order to redissolve the precipitate. The more chloride of sodium is used for a given volume of the solution of mercury to effect this end, the more oxide is supposed to be in this volume; the error in question increases, therefore, the amount of mercury found beyond the real amount. Since the phosphate of mercury is slightly soluble in the liquor, and since, finally, the solution of chloride of sodium is graduated with regard to this error, this discrepancy is generally very slight. If the method be reversed (*viz.*, if the solution of mercury be poured into a mixture of the solutions of chloride of sodium and phosphate of soda) a slight excess of solution of mercury is always added, to make the precipitate appear, because it does not become permanent until the liquor is saturated with it. According to this mode of proceeding, therefore, the amount of mercury obtained is too low.

The determinations become still more exact, if both methods are combined in the following manner:

(Method I).—10 cub. cent. of the solution of mercury are poured into a beaker, 3 to 4 cub. cent. of a solution of phosphate of soda added, and then immediately, without waiting till the precipitate has become crystalline, the solution of chloride of sodium is added from the burette, until the precipitate has disappeared. Suppose 12·5 cub. cent. of solution of chloride of sodium had been used for this purpose, 12·5 cub. cent. of the same solution are then measured off.

(Method II).—3 to 4 cub. cent. of phosphate of soda added, and the same solution of mercury poured into this mixture from the burette, until a precipitate appears. Suppose 10·25 cub. cent. of the solution of mercury have been used for this purpose, then the true amount is as follows:

There have been used for:

I.	10	c. c. of solution of mercury,	12·5	c. c. of solution of chloride of sodium.
II.	10·25	c. c. " " "	12·5	c. c. " " "
	20·25		25·0	

Now, since every cub. cent. of solution of chloride of sodium corresponds to 20 milligrammes of protoxide of mercury, the 25 cub. cent. used indicate $20 \times 25 = 500$ milligrammes of protoxide of mercury which are contained in 20.25 cub. cent. of the solution of mercury.

The following experiments may serve as a critical illustration of this method :

a. 7.480 grms. of pure mercury, and 24 grms. of nitric acid of 1.402 spec. grav., were put into a beaker, and evaporated in a water-bath to the consistence of a syrup, then mixed with water so as to bring the volume of the liquor to 400 cub. cent. 10 cub. cent. of this solution contained, therefore, 187 milligrammes of mercury.

When tested according to method I. it was found to contain 190.8 milligrms.

And according to method II. 184.8 „

Mean 187.8 „ of mercury.

b. 6.993 of mercury dissolved in nitric acid in the same manner, and diluted to 400 cub. cent ; 10 cub. cent. contained 174.8 milligrammes of mercury :

Found according to the method I. . 177 milligrammes

„ „ „ „ II. . 172.4 „

Mean 174.7 „ of mercury.

c. 8.321 of mercury dissolved in the same manner, and diluted to 500 cub. cent. ; 10 cub. cent. contained 166.4 milligrammes of mercury :

Found by the method I. . . 170.2 milligrammes

„ „ „ II. . . 163.4 „

Mean 166.8 „ of mercury.

d. From 10 cub. cent. of a solution of an unknown amount of oxide there was obtained by precipitation with potassa, 1.436 grms. of protoxide of mercury, and by the test-liquors in the mean, 1.416 grms.

e. 31.669 of mercury dissolved in nitric acid in the manner described above, and diluted with 443 cub. cent. of water ; 10 cub. cent. contained 772 milligrammes of oxide. 1 volume of this solution was mixed with 3 volumes of water ; 10 cub. cent. of this dilute liquor contained 193 milligrammes of oxide.

Found by the method I.	. .	192·5 milligrammes	
„ „ „ II.	. .	183·	„
Mean		187·9	„ of oxide.

Instead of phosphate of soda, pyrophosphate of soda, neutral chromate of potassa, and other salts which do not precipitate corrosive sublimate, may be used.

As a matter of course, this method is only applicable to nitric solutions of mercury, containing no metals that are precipitated by alkaline phosphates from their hydrochloric solution. A separation of the mercury from many other metals, may, however, be pretty readily effected by precipitating the solution of the mixed metals with phosphate of soda, then adding a solution of chloride of sodium in excess, and filtering; the mercury is dissolved under these circumstances, whilst the other metals remain undissolved in form of phosphates.

METHOD FOR THE DETERMINATION OF UREA IN URINE.

The methods just described for the determination of chloride of sodium and of mercury are mainly calculated for the determination of chloride of sodium and urea in urine, and are, perhaps, of particular value for this purpose only.

I will now proceed to describe a new method of determining urea in urine, which equals those now in use, in point of accuracy, but has this advantage, that it far excels them as regards rapidity of execution, and that its application does not require any particular skill, so that it is particularly applicable, as I think, for medical purposes, as a means of assisting the diagnosis of certain states of disease.

This method is based on the fact that urea is precipitated by nitrate of protoxide of mercury.

On gradually adding to a dilute solution of urea an equally dilute solution of nitrate of protoxide of mercury, and neutralizing the free acid of the mixture from time to time by baryta-water or dilute carbonate of soda, a flocculent, snow-white precipitate is obtained, which is insoluble in water. If the addition of the salt of mercury and of carbonate of soda, be continued alternately, as long as this precipitate is formed, a point is arrived at, when by the addition of the carbonate of soda, the mixture, or the spot with which the drop comes in contact, assumes a yellow colour of hydrated oxide of mer-

cury, or basic nitrate of protoxide of mercury. When filtered at this point, the liquor no longer contains any appreciable quantity of urea; all the urea is precipitated. I have subjected to analysis this precipitate, which differs by its amorphous condition from the above-described compounds of urea and nitrate of protoxide of mercury, and I found it in every instance to contain 4 equivs. of protoxide of mercury for 1 equiv. of urea. By mixing a solution of urea with a solution of mercury, both of known strength, it can easily be demonstrated, that a precipitation of yellow oxide by the addition of carbonate of soda to the mixture, is not produced until a volume of the nitric solution of mercury is added, which contains 77 parts of protoxide of mercury, for 10 parts of urea in the solution of urea; this, however, amounts to 4 equivs. of protoxide of mercury to 1 equiv. of urea.

On adding nitrate of protoxide of mercury to a solution of urea as long as a precipitate is formed, the mixture remains *white* on addition of carbonate of soda; if, however, the original mixture be left quietly for some hours, the appearance of the precipitate is changed; it becomes crystalline; the six-sided tablets of the compound with 3 equivs. of protoxide of mercury are easily recognised in it, and the clear liquid, standing above the crystals, which was previously precipitated white, produces now a *yellow* precipitate with alkalies. The compound with 4 atoms of protoxide of mercury, is reduced in the acid liquor into a compound containing less oxide—that is to say, part of the oxide is redissolved.

In order to ascertain whether the exact quantity of the salt of mercury has been added, necessary for the formation of the urea-compound with 4 atoms of protoxide of mercury, it is requisite to neutralize the liquor with carbonate of soda, after the mercurial solution has been added. If the mixture—for instance, a drop of it on a watch-glass, mixed with a drop of solution of carbonate of soda—remain white, it may be assumed with certainty that free urea is still present in the liquor; only when on mixing the two drops, a yellow skin appears on the surface, the limit is attained, or rather a little exceeded; but a very slight excess of the mercurial solution is required to indicate that the requisite quantity for the precipitation of the urea has been added. From this it is evident that if the amount of mercury in the solution be known, the quantity of urea in a liquid containing it may be estimated by the amount of solution used, in the described manner, for the precipitation of the urea. Or if for the precipitation of a *known* quantity of urea—say 100 milligrammes—a certain volume of solution of mercury be necessary, an equal volume of it will indicate the same amount of

urea in a liquor, the amount of urea in which is unknown. From the volume of this solution, used for the precipitation, the quantity of urea present may be calculated; the consumption of half the volume indicates half as much; that of double the quantity, twice as much urea in the liquor.

On this point also my experiments have yielded perfectly concordant results, as the following numbers will show.

The first series indicates the amount of urea obtained from 10 cub. cent. of the solution by simple evaporation. The second series exhibits the amount of urea in the same volume of the same solution, as found by the determination with the graduated solution of nitrate of protoxide of mercury.

For 10 cub. cent. of solution of urea were obtained :

	I.	II.	III.	IV.	V.	
I. Urea by evaporation	371·5	412·	117·	98	512	milligrms.
II. „ by nitrate of mercury	372·5	412·	116·8	98	512·75	„

The methods for the determination of urea, up to the present time acknowledged as the best, are those of Ragski and Bunsen; both are based upon the same principle—viz., upon the transformation of the urea into carbonate of ammonia. Ragski determines the ammonia in the form of ammonio-chloride of platinum; Bunsen determines the carbonic acid in form of carbonate of baryta. Both methods give very trustworthy results, if in Ragski's method the potassio-chloride of platinum, precipitated simultaneously, be taken into account.

The following series of experiments, in which the amount of urea in urine of man was determined according to Ragski's method, and by means of nitrate of protoxide of mercury, may prove that the latter method is not inferior to the former.

20 cub. cent. of urine of different individuals contained of urea :

Determined by means of	I.	II.	III.	IV.*	
nitrate of mercury	450	360	450	508	milligrms.
Determined by Ragski's method	446	350	457	508	„

I have found on precipitating urine with a mixture of nitrate of baryta and baryta-water, filtering off the phosphate and sulphate of baryta, evaporating the liquid, extracting the residue with alcohol, evaporating the alcoholic extract to dryness, and again exhausting it with absolute alcohol, that this alcoholic solution contains tolerably

* These determinations have been made by my assistant, Dr. Mayer.

pure urea, crystallizing from it in colourless needles. This method may be used to prepare urea directly from the urine without precipitating with nitric acid; and this mode of proceeding may even be used for the quantitative determination, as the following experiments will show, for which the same urine was used as in the above determinations of urea.

	In 20 c. c. of urine.				In 10 c. c. of urine.*		
	I.	II.	III.	IV.	V.	VI.	VII.
Urea by alcohol.	428	326	439	503	223	219	198.5 milligrms.
„ by nitrate of protoxide of mercury	450	360	450	508	225	220	200 „

The solubility of chloride of sodium in alcohol is, however, somewhat increased by urea. According to an experiment made on this point, alcohol dissolved from a mixture of chloride of sodium and urea 1.0085 grms. consisting of 0.9785 urea, and 0.030 chloride of sodium. 100 parts of the dissolved substance contained accordingly 2.97 of chloride of sodium, and 9.703 of urea.

Finally I determined the urea by means of nitrate of protoxide of mercury in the urine of different persons, and then, in order to test the influence of the other constituents of urine, I mixed the same urine with weighed quantities of pure urea, and determined the latter again: the following results will show that these other constituents exert no influence in the determination.

10 cub. cent. of urine contained:

	I.	II.	III.	
Urea	272	212	170	} 195 milligrms. of urea.
After adding	100	372	250	
The second determination gave	373	462	25	
		464	196	„ „ „

In all the experiments with the test-liquor, the urine was previously precipitated with a mixture of baryta-water and nitrate of baryta, an operation which was omitted in the application of Ragski's method.

Preparation of the solution of Mercury, which serves for the precipitation of Urea in Urine.—4 grms. of pure urea are first dissolved in water, and diluted with water until the volume of the solution amounts to exactly 200 cub. cent. (by dissolving 4 grms. of urea in 200 cub. cent. of water, 201.75 cub. cent. of liquor would be obtained, an excess of 1.75 cub. cent.)

20 cub. cent. of the solution of nitrate of protoxide of mercury, to be used for the determination of urea in urine, should exactly suffice to indicate with precision the urea in 10 cub. cent. of the solution of

* These determinations were made by my assistant, Dr. Mayer.

urea just described, containing 200 milligrammes of urea: 1 cub. cent. of it should correspond to 10 milligrammes of urea. For this purpose the solution of mercury should contain a quantity of oxide sufficient to form with 100 milligrammes of urea, the nitrate with 4 equivs. of protoxide of mercury, besides a small excess of protoxide of mercury, for the purpose of indicating the complete precipitation of the urea; so that, on adding the last drop of the 10 cub. cent. of solution of mercury to the solution of urea, a distinct yellow colour is perceptible, when a few drops of the mixture are mixed with solution of carbonate of soda.

I have found by a series of experiments that for 100 milligrammes of urea, which require, according to calculation, 720 milligrammes of protoxide of mercury (in the form of nitrate), 10 cub. cent. of the solution of mercury should contain 772 milligrammes of protoxide of mercury, in order to produce a distinct reaction of protoxide of mercury in dilute liquids. Every cub. cent. of the liquor should, therefore, contain an excess of 5.2 milligrammes of protoxide of mercury. The test-liquor is best obtained by dissolving pure metallic mercury in pure nitric acid in a beaker; keeping the mixture heated, with frequent addition of some nitric acid, until no longer any trace of nitrous vapours escape; then evaporating to the consistence of a syrup in the same vessel, or a water-bath, and lastly diluting with water, until 100 cub. cent. of the dilute liquor contain exactly 7.140 grms. of mercury. This is the case when for 100 grms. of mercury (converted into nitrate of the protoxide), as much water is added as will bring the volume of the liquor to 1400 cub. cent.

When for the preparation of the nitrate of the protoxide, crystallized nitrate of suboxide of mercury is used, which may with greater facility be obtained in a state of purity and free from other metals than metallic mercury, and a concentrated solution of the salt of the protoxide of unknown strength is thus produced, the amount contained in it has to be determined, and the solution reduced by water to the proper degree. This is done by means of the method described, p. 14. Or a known volume of the concentrated solution is diluted with 10 times its bulk of water, and the amount of protoxide of mercury determined in 10 cub. cent. of it, by precipitation with potassa, or in the form of sulphide of mercury, by mixing the solution with a solution of sulphate of soda, and passing sulphuretted hydrogen through it, till the precipitated basic sulphate of protoxide of mercury is decomposed.

Previous to its application for determining the urea in urine, the dilute solution of mercury must be tested as to its correctness by

means of a solution of pure urea; for this purpose we may use the solution of urea, mentioned above, containing in 10 cub. cent. 200 milligrammes of urea.

It is advisable, in diluting the concentrated solution of mercury not to reduce it, by the addition of water, at once to the calculated degree; but to add rather less water at first, then test it with the solution of urea, and complete the process.

The best mode of proceeding is, to dilute 10 cub. cent. of the concentrated solution of mercury with 5 or 10 times its volume of water, according to concentration, and to determine approximately the amount of protoxide in 10 cub. cent. of this dilute solution, by means of phosphate of soda and the graduated solution of chloride of sodium.

Suppose, for 10 cub. cent. of the five times diluted solution of mercury, 18.5 cub. cent. of solution of chloride of sodium have been used; the amount of water to be added may then easily be calculated.

For 10 cub. cent. of the concentrated solution should be used 38.5 cub. cent. of solution of chloride of sodium (corresponding to 772 milligrammes of protoxide of mercury); there have been actually used $5 \times 18.5 = 92.5$ cub. cent. of the solution of chloride of sodium. If then 92.5 cub. cent. solution of chloride of sodium be used for 10 cub. cent. of the concentrated solution of mercury, then exactly 4.16 cub. cent. of it are necessary for 38.5 of solution of chloride of sodium. If, therefore, 416 vols. of the concentrated solution of mercury be mixed with 584 vols. of water, 1000 vols. of a dilute solution are obtained, 10 cub. cent. of which correspond exactly to 38.5 cub. cent. of solution of chloride of sodium.

It is, as before stated, advisable, not to add the calculated quantity at once, but rather less. 10 cub. cent. of the normal solution of urea are now measured off, and then from a burette the approximately diluted solution is added, until a few drops on a watch-glass produce a distinct yellow colour with carbonate of soda. Suppose 19.25 cub. cent. of the solution of mercury were used for this purpose; then for 192.5 cub. cent. of the solution, 7.5 cub. cent. of water have to be added, and with this solution another trial experiment is made. When, after the addition of 20 cub. cent. the appearance of the yellow colour is distinct, the solution of mercury may then be used for determining the urea in urine.

Every possible care must be bestowed on the correctness of the test-liquor, inasmuch as it replaces a balance with which, when defective, the weighings made are the more incorrect, the smaller

the differences in the weights which have to be determined. In the case of an incorrect balance, the error may be met at each weighing; accurate weighings may be made with it; but in the case of a graduated liquid, the corrections must be made before it is used. The volume of the liquor does not add to the trouble, and it is therefore advisable to prepare as large quantities as possible at one time.

The slight excess of the protoxide of mercury in the test-liquor is like the index of the balance; the yellow colour is its deflection, the amount of which must be carefully noted.

The test-liquor is graduated with a solution of urea containing 2 per cent of this substance; 15 cub. cent. of this solution of urea require for the precipitation of the urea, and for indicating its termination, 30 cub. cent. of solution of mercury; 45 cub. cent. mixture are obtained, containing in the whole $30 \times 5.2 = 156$ milligrammes of free protoxide of mercury; every cub. cent. contains therefore 3.47 milligrammes of protoxide of mercury.

If the 15 cub. cent. of solution of urea contain 4 per cent of urea, and to 15 cub. cent. of it 60 cub. cent. of solution of mercury be added, a mixture of 75 cub. cent. is obtained, containing 312 milligrammes of protoxide of mercury; in every cub. cent. 4.16 milligrammes; there is, therefore, an excess of 0.69 milligramme of protoxide of mercury required to produce the original colour.

Careful experiments have proved that, in analyses of urine, when the amount of urea is increasing, an error is committed, tending to diminish the amount of urea; in the case just mentioned, only 59.37 cub. cent. instead of 60 cub. cent. of solution of mercury would be added to make the original colouring appear. In order to remove this error, an addition has to be made—for 15 cub. cent. of urine, and before the test is applied—of $\frac{1}{2}$ cub. cent. of water for every cub. cent. of solution of mercury which has been used over and above 30 cub. cent.; if, for instance 20 cub. cent. more than the 30 cub. cent. be required, we have to add 10 cub. cent. of water. It will always be found that, after the addition of the water, a few drops of the solution of mercury have to be added in order to produce the proper indication.

For the same reasons, when the quantity of urea in urine amounts to 1 per cent only, 15.3 cub. cent. and not 15 cub. cent. of the solution of mercury must be added to 15 cub. cent. of urine, in order to obtain the test; to remove this error, which increases the amount of urea, a deduction has to be made, in the more dilute urines, of 0.1 cub. cent. for every 5 cub. cent. of solution of mercury, used less than 30 cub. cent. If, therefore, 25 cub. cent. of solution

of mercury have been used for 15 cub. cent. of urine, the amount, 249 milligrammes, is expressed by 24.9 cub. cent. of solution of mercury, &c.

For the purpose of determining the urea in urine, a mixture of 2 vols. of baryta-water and 1 vol. of solution of nitrate of baryta, both saturated whilst cold, is first prepared, and 1 vol. of this alkaline liquor mixed with 2 vols. of urine. Here a small glass cylinder of optional capacity is conveniently used, which is first twice filled with urine to overflowing. The aperture of the cylinder is each time covered with a glass plate, causing the excess to flow off; the same cylinder is then filled once with the solution of baryta, and this added to the urine in a beaker. On mixing both liquors, a precipitate is formed, which is filtered off. 15 cub. cent. of the filtered liquor are measured off for each analysis, corresponding to 10 cub. cent. of urine.

To this volume of urine, without previously neutralizing, the graduated solution of the nitrate of protoxide of mercury is added from a burette, the liquor being constantly stirred, and the test applied when no further precipitate is observed, viz., no further thickening of the liquor. To this end, a few drops of the liquor with the precipitate are put into a watch-glass, and then a few drops of solution of carbonate of soda added, proceeding from the rim of the watch-glass; this is best done by means of a pipette of Indian-rubber.* If, after some minutes, the mixture retain its white colour, a further quantity of solution of mercury is to be added; and this process is continued till a fresh sample from the glass exhibits plainly the yellow colour after the addition of carbonate of soda.

The number of cub. cent. is then read off, and the figure obtained corrected, as described above, according to the contents of the urine.

Method of determining Urea in Urine containing Chloride of Sodium.—A series of experiments have proved that the amount of chloride of sodium in urine, when it reaches 1 to $1\frac{1}{2}$ per cent, exercises an influence on the determination of urea by means of nitrate of protoxide of mercury. When 20 cub. cent. of the graduated solution of mercury are added to 10 cub. cent. of the solution of pure urea, carbonate of soda produces in this mixture a distinct yellow colour of precipitated protoxide of mercury; if now 100 to 200 milligrammes of chloride of sodium be added to the mixture, and the test again applied, the yellow colour does not make its appearance

* See Mohr's *Lehrbuch d. Pharm. Tech.* 2 ed. 1853, p. 397.

on the addition of carbonate of soda; and in order to reproduce it, $1\frac{1}{2}$ to $2\frac{1}{2}$ cub. cent. of the solution of mercury have to be added. The determination shows, therefore, 15 to 25 milligrammes of urea too much.

Just the same occurs with urine. Of the many experiments which I have made on this point, I select the following, in order to show plainly this influence: In one portion of urine the amount of chloride of sodium was first determined; then, in an equal quantity, the urea by means of nitrate of protoxide of mercury. This determination was repeated with an equal volume of urine, after the chlorine had been removed by nitrate of silver; finally, the urea was determined according to Ragski's method in the same quantity of urine.

10 cub. cent. of urine contained milligrammes of urea :

	Chloride of sodium.	Before removing the chlorine.	After removing the chlorine.	According to Ragski's method.
I. . .	145	245	225	223
II. . .	155	210	180	175
III. . .	135	245	225	225.5

In Experiment I. the test indicated, before the chlorine was removed, 20; in II. 30; in III. 20 milligrammes of urea more than was actually contained in it. When the quantity of chloride of sodium amounts to more than 2 per cent., this error does not proportionally increase, but remains constant within certain limits.

It has been seen from the method of determining chloride of sodium by means of nitrate of protoxide of mercury, that a solution of urea containing chloride of sodium is not precipitated by nitrate of protoxide of mercury, until the chloride of sodium is completely transformed into corrosive sublimate. In a solution of 200 milligrammes of urea, and 10 milligrammes of chloride of sodium in 10 cub. cent. of water, to which have been added 20 cub. cent. of the solution of mercury, the excess of the salt of mercury (which would have produced the yellow colour on addition of carbonate of soda) is not contained in form of nitrate, but of corrosive sublimate, and it is evident that the change in the indication is effected by the formation and presence of the corrosive sublimate. Instead of 3.46 milligrammes of protoxide of mercury in the form of nitrate, the mixture contains the same amount of oxide in the form of corrosive sublimate.

On diluting a solution of corrosive sublimate with water, until it yields with carbonate of soda a distinct brownish-yellow precipitate of

oxychloride of mercury, then mixing the same solution of sublimate with a drop of nitric acid, and adding it to the carbonate of soda, the mixture of both remains clear; no precipitate is formed, or at most only a slight whitish cloudiness, from which, after long standing, single brownish-yellow tablets are deposited. In this condition, however, the excess of corrosive sublimate is contained in the mixture of the solutions of urea and of mercury; it contains the greater portion of the nitric acid of the latter in an uncombined state.

By this nitric acid, part of the carbonate of soda is converted into bicarbonate, which does not precipitate corrosive sublimate. When the mixture contains a larger amount of corrosive sublimate, in consequence of a larger amount of chloride of sodium in urine, the liberated carbonic acid is not sufficient to prevent the precipitation of all the protoxide of mercury; a brownish-yellow precipitate is now formed. This appears to me to be the cause why the indication of the complete precipitation of the urea is deferred, by the presence of a certain quantity of chloride of sodium, and why the limit of the reaction is not still further removed, when the amount of chloride of sodium is increased.

With urine containing 1 to $1\frac{1}{2}$ per cent of chloride of sodium, the correct number of milligrammes of urea in 10 cub. cent. of urine may be obtained at once by subtracting 2 cub. cent. from the number of cub. cent. used for the solution of mercury; and even when the amount of chloride of sodium in the urine of different individuals varies within certain limits, the differences obtained in the amount of urea are still correct, and comparable with each other; only in the absolute quantity there is an error which, uncorrected, amounts to 15 to 20 milligrammes for 10 cub. cent. of urine.

In determinations in which the absolute quantity of urea in urine is of importance, the chlorine in the urine must be removed, and the chloride of sodium converted into the nitrate; this is done by means of nitrate of silver. For this purpose a solution of silver is prepared from 11.601 grms. of fused nitrate of silver, which are dissolved in water and diluted until the volume of the solution amounts to 400 cub. cent. 1 cub. cent. contains 29.01 milligrammes of nitrate of silver corresponding to 10 milligrammes of chloride of sodium.

The solution of mercury, the preparation of which has been already described, pp. 8, 9, corresponds with this solution of silver; both indicate, when used in equal volumes, the same amount of chloride of sodium. If, therefore, 12.5 cub. cent. of the solution of mercury had to be added to 10 cub. cent. of urine until the appearance of

the cloudiness, the chlorine in the same volume of urine will be completely separated by 12·5 cub. cent. of silver-solution, whilst no silver remains dissolved.

Since the quantity of silver-solution to be added to the urine containing chloride of sodium, for the removal of the chlorine, may be ascertained in a few seconds by means of the solution of mercury, this operation loses all inconvenience, whilst otherwise it would be tedious, and require much time.

Suppose, for 15 cub. cent. of the urine precipitated by the solution of baryta (containing 10 cub. cent. of urine), 17·5 of solution of mercury had been used; then with the pipette, 30 cub. cent. of the same urine are measured off, and 35 cub. cent. of the solution of silver are added; the liquor is then at once filtered, and of the filtrate always one half of the sum of the mixed liquors taken for the test; in this instance, therefore, 32·5 cub. cent. contain 10 cub. cent. of urine. These are now mixed with the graduated solution of mercury, and the amount of urea ascertained in the manner described, taking into consideration the dilution in consequence of the solution of silver added.

The numerous experiments made by Professors Dr. Vogel and Dr. Bischoff, at whose instigation this method has been devised, leave no doubt as to its applicability and correctness. In describing such a proceeding, numerous difficulties present themselves, which in practice prove to be insignificant; indeed, the description is much more complicated than the execution.

The remarkable simplicity which this method of determining urea and chlorine has attained, is mainly owing to the deep interest which my two excellent friends have bestowed upon my experiments; it is the result of a whole series of methods, which one after the other were rejected, not so much for want of accuracy, but on account of the greater difficulty of execution; and on this occasion I have very plainly seen how important and requisite it is for the purpose in view, when the chemist is solving a physiological problem, does not work by himself alone, but in conjunction with a pathologist and a physiologist.

Chemists will observe that, by this determination of urea, mercury and chloride of sodium, another very interesting problem has been solved—viz. the determination by weight of chloride of sodium, mercury and urea, without having recourse to a balance. The paradox of a determination by weight without weighing, disappears by the consideration, that a solution of chloride of sodium, saturated at the ordinary temperature, contains a definite, unchanging weight

of chloride of sodium, and that in 10 cub. cent. exactly 3.184 grms. of chloride of sodium are obtained ; by dilution with the proper quantity of water, a solution of chloride of sodium is obtained, containing in 1 cub. cent., 10 or 10.852 milligrammes of chloride of sodium. With these solutions, nitrate of protoxide of mercury may be graduated for the determination of chlorine, mercury and urea, without the necessity of using other instruments than a burette and a pipette.

ADDITIONAL REMARKS.

In order to prevent the rapid transformation of urea into carbonate of ammonia, it is requisite, when collecting the urine of animals kept in cages, to wash the bottom of the cage, if made of wood, from time to time, with some dilute nitric acid, and to put a few drops of nitric acid into the vessel in which the urine is collected.

With urine of man and of the dog, 1 vol. of solution of baryta to 2 vols. of urine is generally sufficient to remove all the phosphoric and sulphuric acids, and to leave some baryta in solution. If, however, the urine be alkaline from the presence of an alkaline carbonate, which may be under certain circumstances carbonate of ammonia derived from decomposed urea, 1 vol. of solution of baryta to 2 vols. of urine does not suffice ; in such cases, to precipitate all the carbonic acid, more solution of baryta has then to be used.

When 3 vols. of solution of baryta are mixed with 4 vols. of urine, 17.5 cub. cent. of the liquor filtered off (corresponding to 10 cub. cent. of urine) must be taken for the determination of urea. Of a mixture of equal volumes of solution of baryta and of urine, 20 cub. cent. must be taken for the test, and so on.

I have investigated the influence of the putrefaction of urine on this method of determining the urea, and have frequently obtained the same results with putrid urine, provided the decomposition had not progressed too far, as with the same urine in the fresh state. If, after the addition of 19.5 cub. cent. to the fresh urine, the yellowish colour of the protoxide of mercury made its appearance, the same reaction ensued with urine which had stood for one or two days, after using the same portion of solution of mercury. This can, however, not be depended upon, as the following results will show.

For the precipitation of urine with nitrate of protoxide of mercury were used, for :

10 cub. cent. of urine, whilst fresh	27	cub. cent. of solution of mercury.
10 „ „ of the same urine, after having stood for one day	27	„ „ „
10 „ „ of the same urine, after the third day	27.5	„ „ „
10 „ „ of the same urine, after the fourth day	28	„ „ „

For another sample of dog's urine there were used, for :

10 cub. cent. whilst fresh	36.5	cub. cent. of solution of mercury.
10 „ „ two days old	41	„ „ „
10 „ „ three days old	42	„ „ „
10 „ „ four days old	42	„ „ „

One equivalent of urea yields by its putrefaction 2 equivs. of ammonia; and if, by adding the solution of mercury, the compound described by C. G. Mitscherlich and Kane were formed, which contains 2 equivs. of mercury for 1 equiv. of ammonia or amidogen, just as much of the solution of mercury would be required for its precipitation as for the urea from which the ammonia has been formed. The experiments show, however, that somewhat more is required, which seems to indicate that, under these circumstances, ammoniacal compounds, with 3 and perhaps more equivs. of protoxide of mercury, are formed.

For exact determinations, no other resource is left than to determine the quantities of urea and of ammonia present, each separately, and to express the ammonia found, as urea. For this purpose, two portions of urine are taken; the first of which is used for the determination of the urea, the other for that of the ammonia.

In estimating the urea in this urine, it is not precipitated with the usual mixture, but only with baryta-water; of the liquor filtered off, a volume is taken, containing 10 cub. cent. of urine, and this is then heated in a water-bath, until no further escape of ammonia is perceptible. Since, after the treatment with baryta, the ammonia is in solution in form of caustic ammonia, its expulsion is readily effected; care is, of course, to be taken, that all the carbonate of ammonia is decomposed, and the addition of the baryta-water has to be regulated accordingly.

In the other portion of the urine, the ammonia is determined by means of one of the ordinary alkali-metrical methods. For this purpose it is best to use a dilute sulphuric acid, made with 16.333 grms. of pure hydrated sulphuric acid and so much water that the

mixture occupies 500 entire, or 1000 half cub. cent. $\frac{1}{2}$ cub. cent. of this sulphuric acid saturates exactly 5.66 milligrammes of ammonia; this is the quantity formed from 10 milligrammes of ammonia; 1 cub. cent. of this sulphuric acid used in saturating the ammonia in urine corresponds therefore to 20 milligrammes of urea.

These determinations are somewhat more precise when a measured volume (containing a known quantity of urine) of the urine, treated with baryta, is submitted to distillation, and the product collected in a receiver, containing a measured volume of the above dilute sulphuric acid, which must be larger than is requisite to neutralize the ammonia passing over; the quantity of free acid left is then determined by means of a dilute solution of ammonia, graduated for the dilute sulphuric acid. Thus, if 40 cub. cent. of the dilute sulphuric acid have been put into the receiver, and afterwards 15 cub. cent. of the graduated solution of ammonia were required to saturate the free acid left, a quantity of ammonia was obtained by the distillation corresponding to $40 - 15 = 25$ cub. cent. of the dilute sulphuric acid, or to 250 milligrammes of urea.

II.—*On the Mode of Estimating the Value of Red Prussiate of Potash.*

BY FRANCIS LIESHING.

If the red prussiate were always sold in the form of large crystals, as it usually occurs, the valuation of it would scarcely be required. Since, however, large quantities of this salt are prepared by saturating the powdered yellow prussiate with chlorine, and the product obtained (which necessarily must contain a certain amount of chloride of potassium, and besides frequently contains a portion of undecomposed yellow prussiate) is sold in a powdered state, it becomes a matter of importance to have an easy method of determining the real amount of pure ferrieyanide of potassium it contains, and likewise of checking any adulteration with other ingredients.

The methods of valuation, which, on account of facility and quickness of performance, have lately become very useful, are the so-called alkalimetric methods of estimation; and it is this direction that I have followed to obtain a test for the ferrieyanide of potassium.

If the object is merely to compare several samples of red prussiate as to their relative value, or to compare them with a standard of a pure

and carefully dried drug, a diluted solution of sulphide of sodium, containing a considerable excess of the alkali, may be employed. A certain weight, say 50 or 100 grains, of the pure ferricyanide is dissolved in a few ounces of water, and into this a diluted alkaline solution of sulphur is poured in small portions from an alkalimeter. By each addition, a quantity of sulphur is precipitated, forming a milky liquid, which is of the purest white at the very point of saturation—that is to say, when all the ferricyanide has been converted into ferrocyanide. To determine, however, this point more accurately, a strip of white filtering paper, dipped beforehand into a solution of acetate of lead, and dried, is introduced into the liquid. So long as any red prussiate is present, the paper will remain white, but the slightest excess of the sulphide will give it a brownish tinge. After noting the number of measures consumed, the same solution of sulphur is applied to the samples about to be tested; or it may be diluted before this, so that each measure shall correspond to $\frac{1}{2}$ grain or $\frac{1}{4}$ grain of pure prussiate. If any of the samples should contain metallic admixtures, this would at once be indicated by the test. The liquid would in this case appear white at the very point of the complete transformation of the ferricyanide, but the next drop of the sulphuret added would colour it.

The reaction which takes place in the process described is the following: 1 equiv. of ferricyanide of potassium = $K_3 Fe_2 Cy_6$ decomposes 1 equiv. of sulphide of sodium by taking up 1 equiv. of sodium, and thus forming 2 equivs. of ferrocyanide of potassium = $3K \left. \begin{array}{l} \\ Na \end{array} \right\} Fe_2 Cy_6 + 6HO$, in which 1 equiv. of K is replaced by 1 equiv. of Na.

The soluble iodides are likewise decomposed by red prussiate in the same way as the sulphides, and iodine is set free. This is especially the case when the mixture is heated.

In order to obtain, however, a test of more stability and better fitted for preservation than the sulphide of sodium, I prepared and tried the following three compounds:

Sulphantimoniate of sodium ($3 NaS \cdot Sb S_5 + 18 HO$),

Sulphostannate of sodium ($NaS \cdot Sn S_2$), and

Terbasic sulpharsenate of sodium ($3 NaS \cdot As S_5 + 15 HO$).

But although these three compounds exercise the same decomposing action upon the red prussiate, I found only the sulpharsenate to possess sufficient stability to remain quite unchanged in stoppered bottles for a long period of time.

This compound may be easily prepared, either by dissolving pentasulphide of arsenic in liquid sulphide of sodium, or by dissolving arsenious acid in caustic soda at boiling heat, and adding from time to time a concentrated solution of sulphur in caustic soda, continuing the additions to the boiling liquid, till no further precipitation of sulphur takes place.* After filtering and cooling, a large crop of pale yellow crystals is obtained, which should be separated from the mother-liquor, washed with cold water, dissolved and crystallized again repeatedly, until they dissolve without leaving any residue, and appear perfectly transparent. They are then to be dried upon filtering paper at the common temperature, and preserved for use in a stoppered bottle. The crystals are usually short rhomboidal tables, but they assume a longer columnar form, and become at the same time more transparent, when a little carbonate of soda has been added to the solution. When dried at the common temperature and afterwards heated to 100° C., they lose 33.1 per cent of water of crystallization, and dissolve again, without leaving any residue, or having undergone any decomposition. The solution is pale yellow, and may be kept for a long time without decomposition, especially when mixed with pure carbonate of soda or potash.

The sulpharseniate of sodium is readily decomposed by all acids, as well as by chlorine and by red prussiate of potash. By the action of acids, pentasulphide of arsenic is immediately precipitated, with evolution of sulphuretted hydrogen gas. A neutral solution of red prussiate of potash, when mixed with small portions of a solution of the sulpharseniate, becomes at first only opalescent; by further additions it turns acid, and yellow sulphide of arsenic is then likewise precipitated, with evolution of sulphuretted hydrogen. If, however, either the prussiate or the sulpharseniate has been mixed with a certain quantity of pure carbonate of soda, the pentasulphide of arsenic likewise undergoes decomposition. The liquid becomes milky from separation of pure sulphur, and its green tint turns whiter by each addition, until, after complete transformation of the ferricyanide, it exhibits the purest white. This point of saturation may easily be recognised from the purity of the white; but, to be sure that all the ferricyanide has been converted into ferrocyanide, a few drops of a cochineal-decoction are added, which will immediately be bleached if any ferricyanide is yet present, but in its absence will impart to the liquid a red tinge. In this decomposi-

* It must be remembered here that a much larger quantity of sulphur is required than would appear from the constitution of the salt; since the As O_3 , as well as the Na O , is to be deoxidized at the expense of the sulphur.

tion no formation of sulphurous or sulphuric acid is observed, the precipitate consists of pure sulphur, whilst the pentasulphide of arsenic is apparently only converted into arsenious acid. The process, when the liquid is not alkaline, is probably as follows: 3 eqivs. of ferrieyanide of potassium = $3 (3 \text{ K} \cdot \text{Fe}_2 \text{ Cy}_6)$ will take from 1 equiv. of sulpharseniate of sodium = $3 \text{ Na S} \cdot \text{As S}_5 + 15 \text{ HO}$, 3 eqivs. of sodium, setting free 3 eqivs. of sulphur and 1 equiv. of pentasulphide of arsenic, and forming $\left. \begin{matrix} 9 \text{ K} \\ 3 \text{ Na} \end{matrix} \right\} \text{Fe}_6 \text{ Cy}_{18} + 18 \text{ HO} =$ 6 eqivs. of ferrocyanide of potassium, in which 3 eqivs. of K are replaced by 3 eqivs. of Na. If, however, the liquid be made alkaline, the carbonate of soda added furnishes 3 more eqivs. of sodium, again to form with 3 eqivs. of ferrieyanide of potassium $\left. \begin{matrix} 9 \text{ K} \\ 3 \text{ Na} \end{matrix} \right\} \text{Fe}_6 \text{ Cy}_{18} + 18 \text{ HO} =$ 6 eqivs. of yellow prussiate, the 3 eqivs. of oxygen separated from the soda, joining with 1 equiv. of arsenic and forming 1 equiv. of arsenious acid, which again will combine with 1 equiv. of soda.

Assuming thus, that 6 eqivs. of red prussiate would form, by the action of 1 equiv. of sulpharseniate of sodium and 3 eqivs. of soda, 12 eqivs. of yellow prussiate of potash, calculation shows, that for every 100 grains of pure red prussiate, 20 grains of crystallized $3 \text{ Na S} \cdot \text{As S}_5 + 15 \text{ HO}$ are required; and this is the exact proportion which has also been found by experiment.

We weigh, therefore, on the one hand 100 grains of the red prussiate to be tested, and dissolve it in 2 ounces of water; on the other, 20 grains of the sulpharseniate and from 40 to 60 grains of pure carbonate of soda or potash; these are dissolved together in the alkalimeter in 400 measures of water, so that each measure consumed (containing $\frac{1}{20}$ th of a grain of sulpharseniate) would indicate $\frac{1}{4}$ per cent of pure red prussiate. When after gradual addition the mixture has acquired a pure white, the complete transformation may be ascertained by a drop of cochineal liquor.

Attention must be paid to the circumstance, that all commercial soda contains small quantities of sulphur, which would interfere with the exactness of the test. This is less the case with pearl-ash; but it will be best to employ carbonate of soda or potash especially purified for the purpose.

Whilst in the above process the pentasulphide of arsenic contained in the sulpharseniate of sodium is converted by red prussiate into arsenious acid, it is, on the contrary, converted into arsenic acid by the action of hypochlorite of lime. This will appear from the follow-

ing experiment: If to a solution of arsenious acid in an excess of soda, which has been coloured by a few drops of cochineal-decoction, the slightest quantity of red prussiate be added, the colour will be destroyed immediately, the arsenious acid not serving here as a protection; the same liquid will however keep its tint after considerable additions of hypochlorite of lime. The same behaviour towards hypochlorite of lime is exhibited by a solution of red prussiate after complete transformation by sulpharsenate, whilst an alkaline cochineal-decoction, alone or mixed with yellow prussiate, is immediately bleached by the hypochlorite. It is besides a peculiarity of an alkaline solution of cochineal, that its decolorization by red prussiate or chlorine is instantaneous, and much easier to discern than that of an acid solution. Amongst a number of colouring matters, I found only indigo-carmin in connection with carbonate of soda equally sensible for the above two agents; and this may easily be accounted for, if we remember that indigo-carmin, as well as cochineal, is acted upon and gradually discoloured by alkalis alone.

As to objections which may be made against the sulpharsenate-test, I remark first, that the alkalimetric methods of valuation in general are not sufficient of themselves, and should always be preceded by a qualitative examination of the drug; otherwise the most injurious admixtures might frequently be overlooked. As an illustration of this, I need only refer to the otherwise very accurate test lately proposed by Dr. Penny* for the valuation of tin in the "crystals of tin" and the "double muriate of tin" of commerce, which is based upon the conversion of the protochloride of tin into bichloride by bichromate of potash. In this instance, the liquid "double muriate of tin" might contain a very considerable admixture of protochloride of iron, without even changing its external appearance; and this in practice highly obnoxious admixture, would, by the sole application of the bichromate of potash test, not only escape detection, but the iron would actually be calculated as tin. Supposing then, that certain impurities might occur in the red prussiate, which in acting alike upon the sulpharsenate might give rise to errors, the agents which would require attention, are principally acids, chlorine and hypochlorites, chlorates, sulphides and sulphites, and metallic combinations.

As to the acids, it is evident that their action will be neutralized by the excess of alkali in the test-liquor, and any acidity in the

* Chem. Soc. Qu. J. IV, 239.

prussiate might besides be saturated beforehand by an addition of alkali. The presence of free chlorine and of hypochlorites would be indicated by the smell, and could only occur in a fresh preparation of the powdered kind of red prussiate, the chlorine being neutralized in a short time by the action of the prussiate itself. Chlorates do not seem to have any effect upon the test. Sulphides and sulphites could not coexist with red prussiate. Metallic compounds would, with few exceptions, either be indicated in dissolving the prussiate, or by the test itself; and as the red prussiate is always first decomposed by the sulpharseniate, the metallic bases would only combine with the sulphide after the point of saturation, and therefore not come into calculation.

Another objection which might be started is, that the carbonated alkali alone might decompose the red prussiate, and that consequently, the quantity to be added is not indifferent. Such a decomposition does in reality take place; but when the mixed solutions are not heated, the action is so slow, that it is scarcely to be observed after a day or two.

It must, however, be allowed that the preparation of the sulpharseniate of sodium, and especially the drying of the crystals, requires much attention; and it would perhaps be preferable to dry them at once at 100° C., and to employ the anhydrous powder.

III.—*On an Improved Assay Balance.*

BY GEORGE H. MAKINS.

Having occasion, some little time since, for an assay balance, and being well aware of the points wherein those in use here are deficient, I applied myself to the task of so arranging existing materials, as to produce, if I could, a more effective instrument.

Two forms of assay balances are most common in England. The first is very little more than an exceedingly delicate pair of ordinary scales; in fact, a very light scale-maker's beam, adjusted, as they are accustomed to do, by carefully "setting" it, so as to obtain correct length of arm, and straight line of fulcrum and points of suspension. The second is an instrument imported from France, or better, made here upon the French plan. Of these, the French are but an improvement upon the first class; the beams (of almost all) being permanently adjusted when finished. Those, however, made by

Mr. Oertling upon this plan are furnished with the requisite adjustments, and are very superior in point of detail and workmanship. But the beams of all contain too much metal, and that especially in parts where its presence interferes with their action, by imparting a certain amount of inertia. And, lastly, their stands and movements are very far from convenient.

The essentials in an assay balance appear to be these: first, that it should be constant, so that certain differences of value in weights should always produce the same difference of indication; secondly, it should be exceedingly quick in indicating; and, thirdly, very sensible, and consequently well affected by slight differences.

These two last requirements are somewhat incompatible, for, in proportion as you increase quickness of action, you must diminish sensibility, by lowering the centre of gravity of the system; and it is in the union of these two necessary qualifications that the value of the balance now before the Society lies.

The beam of this balance is what is called a skeleton-beam, 10 inches long, $\frac{1}{2}$ an inch deep at the fulcrum, tapering off to $\frac{1}{8}$ at each end. It is about $\frac{1}{16}$ of an inch thick in the centre, decreasing in the same way to $\frac{1}{32}$ of an inch. As little metal as possible is left in it; thus, in the centre, there is but just enough to allow of secure fixing for the knife-edge; and at the ends, for the adjustments for length of arm, &c. The latter are effected very much in the same way as in Robinson's balance, in which an oblique saw-cut is made nearly through the metal at the ends of the beam, which cut is capable of being opened or closed by pressing-screws. In the present case, a loose piece is put on, and made similarly adjustable by screws. Thus we obtain the adjustment for length of arm.

The bearings for the pendants are two hard steel points, at each end adjustable for the straight line, by having a fine screw cut on each, and provided with fixing-nuts. By these the points can be screwed vertically, up or down, through the horizontal plate formed at the end of the beam.

The pendants are hung on these points by a small steel plate, in the underside of which a cup-shaped cavity is turned for the one, and a groove hollowed out, from the back towards the front, for the other.

Had two cups been employed, it would have been next to impossible, even by the most careful workmanship, to have secured their concentricity with the points. A small steel hook for the pans passes vertically down in a notch in the horizontal plate at the end of the beam.

This last arrangement is due to Mr. Oertling, whom I employed to make this instrument; for in the drawings I sent to him, I had put but a single point at each end, being fully persuaded how much quickness and delicacy are ensured by the least possible friction of the pendants. I had provided against their swinging round, which was almost sure to take place upon a single point, by having the edges of the notches through which they were to pass worked to a kind of knife-edge on each side. Mr. Oertling, however, thought that two would be necessary, and that the friction in them would be less than even if one were used. The weight of the beam, with all its fixed appendages, is only 103 grains. Its bearings are of agate, worked to elliptical surfaces, instead of being as usual, plain. Here, again, but a point of the knife-edge is allowed to bear upon the agate.

Bearing in mind the very small weight these balances would have to carry (and I never load mine with more than 25 grains) I had no hesitation in thus reducing all parts of contact where friction during action occurs, to the smallest possible dimensions, virtually, indeed, to points.

Nor have these parts been found to fail from blunting by wear, as might have been anticipated; at least, in the case of one which I have daily in use, I know that I have made more than ten thousand weighings in it, and not the least diminution of sensibility is as yet observable.

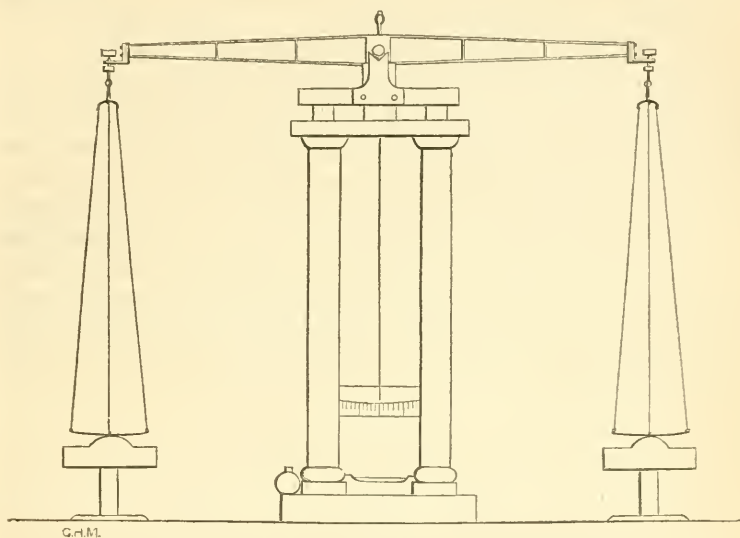
The stand is massive in its construction, in order that when rapidly put into action, no tremulousness may be communicated to the beam.

I give here an outline drawing of the instrument (made to a scale) in order to exhibit its solidity in contrast with the delicacy of the beam and its appurtenances. It consists of two stout pillars, of $\frac{1}{2}$ an inch diameter and $6\frac{3}{4}$ inches long, fixed on a base $\frac{1}{4}$ of an inch thick. Upon the upper end of these is fixed a table, which has two upright pieces rising from it, to which are cemented the agate bearings.

A second corresponding table is attached to the movement rods which pass down the pillars. This table has two mortices in it for the passage of the upright pieces which carry the agates, and upon these uprights it slides up and down. On the outside of this second table is a crutch on each side; these lift off the beam from its bearings when throwing it out of action.

The movement lever on being depressed, first, however, acts upon the arms of two rollers, which are fixed under the lantern, and whose opposite arms depress the ivory tables which support the pans;

this roller motion is particularly free and pleasant in use. By the time the tables are well away, the lever has reached a connecting



stirrup between the movement rods, and begins to drop the beam upon the agates.*

In order to have the smallest possible contact between the under side of the pans and the tables, the latter have hemispherical eminences turned upon them, and the pans themselves have a curve given to them of a radius just equal to the distance between the ivory table and the point of suspension; whereby, should they swing out of the perpendicular during weighing, they will nevertheless be caught by the tables when they rise up to them.

There are adjustments both for the amount of fall of the fulcrum to the agates, and of rise of the ivory tables to the pans; the former is, however, very small in amount.

By the pillars being fixed at a distance of $1\frac{1}{2}$ inch from each other, a good space is obtained for a scale; while, by prolonging the index-needle to rather more than 6 inches downwards, very open degrees are obtained. And besides this great advantage, the motions of the index-needle are brought nearly upon a level with the pans.

To those who are used to a descending index (as in all good

* The movement and "rider" apparatus are both omitted in the above drawing, for the sake of greater distinctness.

chemical balances), the comfort of this arrangement will be at once apparent; for the eye has not to travel a distance between the pans and index (as is the case in the balances to which I just now alluded), but the whole are under view at once.

Much praise is due to the maker for the very beautiful workmanship he has put into these instruments, and that more especially in the beams. Without this perfect degree of execution of the work, they would be uncertain in action, and possess less capability than a heavier instrument.

I have been encouraged by several members who have had opportunities of witnessing its performance, to put a brief description of this instrument before the Society in the form of a notice, and hope that by so doing I have not been occupying time unprofitably. I should have done so last season, but had not one sufficiently long in use to fairly put its powers to the test, before the close of the Society's meetings.

IV.—*On some New Compounds of Tellurethyl.*

(FROM A LETTER OF PROFESSOR WÖHLER TO DR. HOFMANN.)

You are already acquainted with the fact, that some experiments performed at my instigation by Dr. Mallet on telluride of ethyl,* have proved this body to comport itself like an organic radical, like a metal, in fact, and to form both a basic oxide C_4H_5TeO , and a corresponding chloride, C_4H_5TeCl . From the results you obtained by studying the action of iodide of ethyl upon ammonia, the idea suggested itself that this new radical, like ethyl, methyl, &c., might form a tellurethylamine corresponding to ethylamine.

This idea has not, up to the present time, been confirmed by the experiments I have made on this subject; these experiments have led however to the discovery of various compounds, which may be considered as additional proofs of the radical character of telluride of ethyl, and of which I now propose giving you a short account. I may at the same time remark that there appears now a prospect of a more detailed investigation of these remarkable relations, inasmuch as Mr. A. Löwe, of Vienna, whom I also have to thank for

* Ann. Ch. Pharm. LXXIX, 223.

the material employed in these researches, has invented an advantageous process, by which tellurium, till now so rare, is obtained as a by-product in the working of the Transylvanian gold ores, and can thus be introduced in commerce in larger quantity.

1. *Oxychloride of Tellurethyl*, $C_4 H_5 Te O + C_4 H_5 Te Cl$.—This body is produced when chloride of tellurethyl is dissolved in caustic ammonia, or potash, and the solution evaporated to crystallization. It is best to use ammonia, as an excess does not decompose the product. The salt crystallizes easily, as the excess of ammonia evaporates. Chloride of ammonium or of potassium remains in the mother-liquor.

Oxychloride of tellurethyl forms very lustrous, colourless, six-sided prisms, which on heating are decomposed, tellurethyl being separated and metallic tellurium remaining behind. From hot alcohol particularly it may be obtained in beautiful crystals. Hydrochloric acid precipitates from solutions of this substance, colourless oily chloride of tellurethyl, a small quantity of which, with the excess of acid, remain in solution. Sulphuric acid also precipitates chloride of tellurethyl, while sulphate of oxide of tellurethyl remains in solution, from which hydrochloric acid separates another portion of chloride of tellurethyl. Sulphurous acid precipitates from solutions of this oil, a heavy, dark yellow, transparent oil, a mixture of chloride of tellurethyl and of tellurethyl.

From this behaviour, and from the mode of its formation, the composition of this body might have been anticipated; it was however confirmed by analysis. This gave the following numbers :

	Experiment.	Theory.
		$C_8 H_{10} Te_2 Cl O$.
Carbon . . .	19·94	20·89
Hydrogen . . .	4·96	4·35
Tellurium . . .	56·22	55·87
Chlorine . . .	15·49	15·43
Oxygen . . .	3·39	3·43

This body is therefore formed by the alkali replacing in two equivalents of chloride of tellurethyl, half the chlorine by oxygen.

2. *Bromide of Tellurethyl*, $C_4 H_5 Te Br$, is formed when a solution of the above chlorine-compound, or of nitrate of tellurethyl, is mixed with hydrobromic acid. It separates as a pale yellow, very heavy colourless oil.

3. *Oxybromide of Tellurethyl*, $C_4 H_5 Te O + C_4 H_5 Te Br$, is ob-

tained by dissolving the bromide in ammonia. It crystallizes in shining, colourless prisms, of the same form as the corresponding chlorine-compound, with which it is perfectly analogous.

4. *Iodide of Tellurethyl*, $C_4 H_5 Te I$, may be formed by mixing a solution of nitrate, or of oxychloride or oxybromide of tellurethyl with hydriodic acid. It is also formed when free chloride of tellurethyl is supersaturated with this acid, a reaction which explains why, in the decomposition of the oxychloride, iodide of tellurethyl alone is produced, instead of a compound of this body with the chloride. The salt separates in the form of a very fine yellow precipitate, which on washing and drying becomes an orange-yellow powder. When heated in water, it melts at $50^\circ C.$ to a heavy yellowish-red liquid, which on cooling solidifies to a yellowish-red, opaque, scaly, frangible mass, soluble in hot alcohol, from which it crystallizes in long, thin, orange-yellow prisms. It is only sparingly soluble in water. When heated above its fusing-point, it decomposes, yielding a yellowish-red oil, a black sublimate, and metallic tellurium. If in its preparation a partially decomposed solution of hydriodic acid is employed, an almost blood-red precipitate is obtained, containing most probably a higher iodide.

5. *Oxyiodide of Tellurethyl*, $C_4 H_5 Te O + C_4 H_5 Te I$.—This body is prepared by dissolving the iodide in ammonia and allowing it to evaporate spontaneously. It crystallizes readily as the excess of ammonia volatilizes, being readily soluble in this, but only sparingly so in water; it forms pale yellow transparent prisms, isomorphous with the corresponding chlorine and bromine-compounds; the surface becomes orange-yellow on exposure to air. Hydrochloric acid separates from an aqueous solution of this body a yellowish-red heavy mixture of chloride and iodide of tellurethyl. Sulphuric acid precipitates orange-yellow iodide of tellurethyl; from the filtrate, hydrochloric acid afterwards separates colourless chloride of tellurethyl. Sulphurous acid precipitates from the solution of the compound an easily fusible, semi-solid mixture of iodide of tellurethyl and tellurethyl.

It was considered superfluous to analyse these compounds, as their composition is clearly established by their behaviour, and from their mode of formation.

No compound could be obtained with cyanogen.

6. Hydrofluoric acid added to solutions of the oxychloride, throws down chloride of tellurethyl, a soluble fluorine-compound remaining in solution, which may be crystallized by evaporation; the same compound is obtained from free oxide of tellurethyl and hydrofluoric

acid; a deportment in which fluorine again deviates much from the other salt-radicals.

7. *Sulphate of Oxide of Tellurethyl*, $C_4H_3TeO.HO + C_4H_5TeO.SO_3$.—This compound was obtained by adding a neutral hot saturated solution of sulphate of silver to a solution of recrystallized oxychloride of tellurethyl, as long as chloride of silver was formed. The new salt crystallizes in groups of small, short, colourless prisms, easily soluble in water. Sulphurous acid precipitates from its solution a yellow oily body, of a most disagreeable odour. Chloride of barium precipitates sulphate of baryta and reproduces the oxychloride. The percentage of sulphuric acid found was 15.10, the above formula requiring 15.91 per cent.

8. *Oxalate of Oxide of Tellurethyl*, $C_4H_5TeO.HO + C_4H_5TeO.C_2O_3$, was obtained by digesting a hot saturated solution of the oxychloride with excess of oxalate of silver. The salt crystallizes in small groups of short colourless prisms, difficultly soluble in water. On heating it fuses, boils, gives off much tellurethyl and a crystalline sublimate, and leaves metallic tellurium. The percentage of oxalic acid found was 14.86, that of tellurium 51.31; the above formula requires respectively 14.56 and 51.87 per cent.

These two salts, which exhibit an acid reaction, may therefore be considered as double salts, consisting of the neutral sulphate or oxalate combined with hydrated oxide of tellurethyl. I leave it for the present undecided whether the base contained in them is identical with the one obtained by Mallet by direct oxidation of tellurethyl with nitric acid, or by decomposition of the chloride with oxide of silver, or whether its atomic weight is doubled, and the sulphate should be expressed thus: $C_8H_{10}Te_2O_2 + HO.SO_3$.

9. *Oxide of Tellurethyl*.—It appears impossible to solate the base without partial decomposition. It was tried in two ways—namely, first by decomposing the oxychloride with freshly precipitated oxide of silver, and secondly, by precipitating the sulphate with hydrate of baryta. In both cases, an alkaline solution of hydrated oxide of tellurethyl, free from baryta and oxide of silver was obtained, which, however, on evaporation on a water-bath, always evolved an odour of tellurethyl, and left at last a thick viscid mass, of the consistence of turpentine, which would not become solid, and which at this stage of concentration suddenly decomposed with effervescence, as if carbonate had been formed, and was decomposed under these circumstances. When treated with acid, the mass evolved carbonic acid at first, but not after some time; it did not altogether dissolve again in water. With chloride of ammonium it evolved ammonia. Hydrochloric acid

precipitated from its solution oily chloride of tellurethyl. The oxide appears to be insoluble in a concentrated solution of potash; for if some of the crystalline oxychloride is heated with the latter, colourless oily drops separate, which possess the odour of tellurethyl, and redissolve on addition of water.

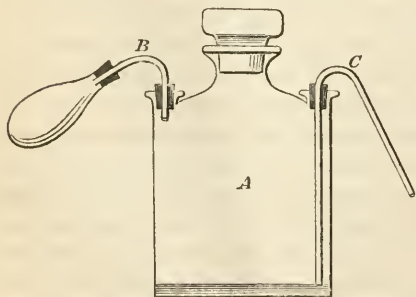
In the next number of the "Annalen" you will find my researches on this subject in detail. As it is to be foreseen that these relations will recur with methyl and the other alcohol-radicals, I have, in consideration of the fecundity of this subject, given a full account of the method of preparing telluride of potassium, tellurethyl and chloride of tellurethyl, as a guide to those who may wish to pursue this investigation.

V.—*Description of an Apparatus for Collecting Gases over Water or Mercury.*

BY W. M. WILLIAMS.

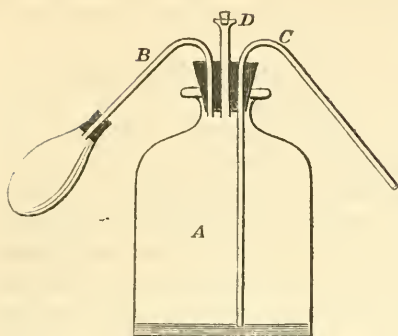
This apparatus is intended to supersede the cumbrous and expensive pneumatic trough and its appendages. It is constructed on the principle of a common wash-bottle, a flask or tube for generating the gas being fitted to the tube corresponding to that to which, in the wash-bottle, the mouth is applied. It may be constructed either with a three-necked bottle, as in Fig. 1, or a common wide-mouthed bottle of sufficient size, as in Fig. 2. In both figures, *A* represents the bottle used as a receiver; *B* the tube to which the generating

FIG. 1.



flask is attached, which terminates in the upper part of the receiver, and may be called the *gas-tube*; *C* is the tube through which the water is forced; this tube, which dips to the bottom of the vessel, we may call the *water- or mercury-tube*. Besides these, there is in the apparatus represented in Fig. 2, a short straight tube *D*, fitted into the cork of the receiver,

FIG. 2.



its lower part terminating like the gas-tube, in the upper part of the receiver. This tube, which is corked or stoppered, may be called the *filling-tube*.

The mode of using the apparatus is very simple and obvious. Suppose we wish to prepare oxygen gas and demonstrate its properties. The receiver is filled with water, and the flask or tube con-

taining the mixture of chlorate of potash and oxide of manganese, fitted by a cork, to the gas-tube, and heat applied; as the gas is generated, it passes through the gas-tube into the receiver, displacing the water by forcing it up the water-tube. The use of the filling-tube *D* is to get rid of the atmospheric air which comes off at first; this is done by taking out the stopper and refilling the receiver with water after the first portion of the gas has been evolved. In the three-necked apparatus, Fig. 1, the middle stopper is used for this purpose. This may be used for demonstration without removing the gas- and water-tubes (on which account the water-tube should be kept as close to the side of the receiver as possible) by simply taking out the middle stopper, which should be large enough to admit the spoon, &c., required in the experiments.

In the apparatus Fig. 2, the cork and all the tubes must be moved together; and when the gas is to be used immediately, it will be found convenient to slip a piece of plate-glass over the neck of the receiver, with the left hand, at the moment the cork holding the tubes is removed with the right. When the gas is to be kept for any length of time, of course a stopper will be required.

A number of bottles may be thus filled with gas by connecting them as a series of receivers, the water-tube of the first being attached by a caoutchouc tube to the gas-tube of the second, and so on. The first only need be filled with water or mercury, which successively fills all the rest as the gas displaces it.

In constructing the apparatus, care should be taken not to make the gas-tube too long, in order that it may easily bear the weight of the generating flask; also to bend it at such an angle as to place the flask at a convenient height for the spirit-lamp, the retort-stand, as well as the retort and pneumatic trough, being thus dispensed with.

The water- or mercury-tube should not be carried too high before bending, in order to avoid unnecessary pressure from the column of fluid to be raised.

The outer end of the water- or mercury-tube should dip into the fluid contained in the vessel which receives the water or mercury driven out, in order to prevent regurgitation of air, which would otherwise take place when the gas in the flask and receiver is cooling, after the generation of gas has ceased.

One of the advantages of this apparatus is the facility with which varying quantities of gas may be collected in the same receiver, as the generation of the gas may be stopped at any stage, when the receiver is a fourth, a third, or half full, and this small quantity of gas experimented upon without disturbing the apparatus; the receiver may then be filled again, more gas made, and so on, any number of times. By taking advantage of this, a mixture of gases in any proportions may be easily made. I have fitted up on this principle a small bottle for exploding the mixture of oxygen and hydrogen gases.

For demonstrating the properties of oxygen on a large scale, a globe might be fitted up on this principle, a layer of sand being kept at the bottom to prevent cracking by ignited iron, &c. The difficulty of keeping sand at the bottom of a globe, which is to be inverted when filled, is by this arrangement obviated.

For collecting gases over mercury, an apparatus fitted up on this principle enables us to attain the minimum of expenditure of mercury; since the quantity required is only equal to the volume of the vessel receiving the gas, and with this any number of such vessels may be filled by connecting them as a series. The precautions before referred to for preventing undue pressure, of course require especial attention in using mercury. This pressure, however, may be reduced to nothing after the mercury-tube is once filled, by keeping the level of the fluid the same, both in the vessel in which the gas is being received, and that into which the mercury driven out is being collected; for when the mercury-tube is filled, and its outside end dips into this vessel, it acts as a syphon. In order to do this, some additional mercury will of course be required. If, however, care be taken to make all the fittings tight, this will not be necessary, except in a very high apparatus.

VI.—*On the Law of Electrolysis.*

BY PROFESSOR H. BUFF.

The law of definite electrolytic decomposition, if not hitherto decidedly opposed, has yet been regarded as doubtful by many physicists. Others have considered it only as approximatively true; among those inclined to this view are Martius,* Schoenbein,† de la Rive,‡ &c. Jacobi, who as late as last year published some experiments on the electrolysis of sulphate of copper,§ is disposed to consider that the intensity of the action depends on the concentration of the solution. The celebrated discoverer of the electrolytic law has admitted, in the 12th series of his experimental researches on electricity, that fluid electrolytes may possibly conduct currents under a certain strength, without being decomposed by them; and that this conducting power, though not equal in different fluids capable of decomposition by electricity, yet in all cases obtains only in very weak currents.

As definite electric decomposition, if rigorously proved, presents a capital method of determining the unit of electricity, inasmuch as this unit would then become identical with the unit of chemical action, it appeared to me of great interest to ascertain by accurate measurements the limits between which the law of Faraday holds good. From the results of an investigation undertaken for this purpose, I consider it as proved, that even the smallest amount of electricity cannot pass through a liquid, capable of being decomposed, without producing an equivalent amount of decomposition.

According to the view generally adopted at present, I regard as electrolytes all chemical compounds which, like water, hydrochloric acid, chloride of lead, &c., consist of an electro-positive radical, which under galvanic influence collects at the negative electrode, and of an electro-negative radical, which is disengaged at the positive electrode. Thus sulphate of copper consists of the positive radical Cu and the negative one SO_4 ; nitrate of silver of the positive radical Ag and the negative NO_6 ; sulphate of ammonia of the positive radical NH_4

* Pogg. Ann. LVIII, 284; Iust. 1850, 30.

† Pogg. Ann. XLIII, 238.

‡ Pogg. Ann. LIV, 403.

§ Petersb. Acad. Bull. IX, 333.

and the negative one SO_4 , &c. According to this view, the electrolytic action remains the same whether the current liberates an equivalent of hydrogen from water, or an equivalent of the radical NH_4 from a salt of ammonia. The question which I proposed to solve was, whether this action is only attendant on currents of certain strength, or whether it takes place proportionately with the weakest currents.

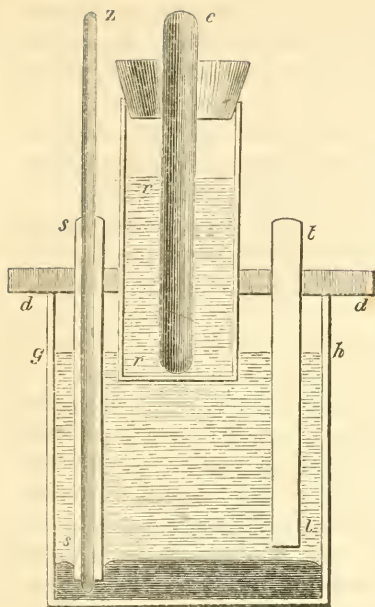
In order to apply very weak currents to electrolytic processes, and yet to separate a quantity of substance sufficient for weighing, it was necessary that a galvanic battery should be arranged as to give a weak but perfectly constant current, for some days at least. None of the known batteries answered this purpose. But as this want of uniform action in the so-called constant batteries arises more from deteriorating influences, than from the principle of their construction, I tried to obviate the former as much as possible, and I succeeded best by a modification of Daniell's battery. A little loss of power is produced in this battery by the zinc being gradually converted by the surrounding acid into sulphate of zinc.

This evil may, however, as is well known, be easily avoided by filling the zinc cell at once with sulphate of zinc. It is true that the resistance to conduction is increased in this way, but this is scarcely worth consideration with a current which has to traverse a long distance. The principal cause of variation in Daniell's battery when currents of long duration but small power are required, is caused by the copper solution gradually passing over by endosmosis into the zinc solution. Not only is copper precipitated chemically by this means, and consequently the equivalent amount of zinc lost for the process; but the copper precipitated on the surface of the zinc of course alters the state of the surface of the electro-positive metal, while it gives rise at the same time to secondary currents, which hasten the precipitation of copper and consequent loss of zinc.

These local currents are moreover the cause of the deposition of copper in the pores of the cells, and of its appearing even on the outer surface of the same.

By the following contrivance, of which the accompanying sketch represents a section, the influence of endosmosis was reduced to a minimum.

A glass vessel with ground edges is provided with a well-fitting cover *dd*, having three apertures, into which are introduced three glass tubes. The middle one *rr*, which should be as wide as possible, is closed at the lower end with bladder; of the two other tubes, *ss* and *tt*, the tube *ss* descends into a layer of mercury covering the



bottom of the vessel, while the other *tt* has its lower aperture at the sulphate of zinc, so that the liquid moistens the porous diaphragm of the tube *rr*. In this tube a solution of sulphate of copper, together with some crystals, is introduced. By introducing a strip of copper *c* into the tube *rr*, and a piece of zinc *z* into the tube *ss*, and connecting *c* with *z*, by means of a conductor, a perfectly constant current is produced, inasmuch as the mercury continually dissolves as much zinc as is necessary to keep up a steady action. Endosmosis is certainly not quite prevented by this arrangement; but it takes place very slowly, the zinc solution being more dense

than that of the copper. As the lower extremity of the zinc is dissolved by the mercury, the rod gradually falls. In order to facilitate the renewal of the sulphate of copper, without deranging the current, the strip of copper is held in its place by a cork, which half fills the opening. The tube *tt* serves to remove from time to time a little sulphate of zinc by means of a pipette, and to replace what is removed by water. Batteries of this description have been in use since the middle of July, without their action having varied, up to the 1st of October, and without the necessity of disconnecting them; towards the middle of the latter month, a slight diminution of the current was perceptible. Upon closer examination, it was found to have arisen from a deposition of oxide of iron in the pores of the bladder, which was otherwise perfect.

Although this battery when in action presents a considerably greater resistance to conduction than the ordinary Daniell's battery, it is nevertheless well adapted for working the electric telegraph, and I have no doubt that, when once applied to this purpose, it will replace all other arrangements.

The advantages it possesses over the ordinary Daniell's battery may be easily seen from the following experiment. One element of the latter was connected with one wire of a galvanometer by means

of two wires of equal length. A deflection of 78° was produced on the galvanometer. A second element of the modified construction, when connected with the other wire of the galvanometer, caused a deflection of $77^\circ.5$.

When both currents were passed simultaneously, but in opposite directions, through the coil of the galvanometer, a deflection of $8^\circ.5$ was produced in favour of Daniell's battery. This decreased in two hours to 8° , in twenty hours to $7^\circ.5$, and continued constantly diminishing. After nine days, the Daniell's battery only caused a deflection of 33° , while that of the modified arrangement remained constant at $77^\circ.5$.

The equivalent of zinc electrolytically consumed for a current of this strength, during an action of 13085 minutes' duration, is 164.6 milligrammes. The actual amount consumed in the constant battery, however, was 1140 milligrammes, or 7 times that quantity, while in Daniell's battery, 27700 milligrammes, or 168 times the quantity of zinc were consumed. These great losses were occasioned by local actions, and would consequently appear less considerable with stronger currents. The constant battery described above has been exclusively used for the following experiments. One and the same pair served throughout the whole investigation, which lasted several months, without its being necessary to disconnect them once; nothing was done to them excepting that from time to time small pieces of sulphate of copper were added.

To determine the relation which the electrolytic action bears to the strength of current, I employed a neutral solution of nitrate of silver. In this were immersed two strips of chemically pure silver, so that under the influence of the battery, silver was dissolved from one strip, while it was deposited upon the other. For the pure metal, as well as for a perfectly pure and neutral solution of nitrate of silver, I am indebted to the kindness of Professor von Liebig, who prepared both himself expressly for this investigation. The alteration of the strength of the current was effected by interposing wires of various lengths. For this purpose I employed two copper wires, perfectly equal and very thin, of such a length that each presented a resistance to conduction equal to that caused by a silver wire of 1.5 millimetres in thickness and 1,800,000 metres in length. It is evident that, in comparison to such an immense resistance, that of the galvanic element, together with that of the decomposing cell, would form only a small fraction. Both were, however, specially measured, and it was found that together they only were equal to $\frac{1}{136}$ th of that produced by the whole length of wire. According as the wires r and r

were introduced successively, or singly, or both together (representing a wire of double section) into the galvanic circuit, three currents were produced, the strength of which bore almost exactly the proportion of 1 : 2 : 4. The weight of silver electrically deposited bore the same proportion, as will be seen from the following table :

Resistance of the wire.	Duration of current.	Weight of deposited silver in milligrammes :	
		Found.	Calculated for 6000 minutes.
$r + r'$	2547 minutes	55.5	130.74
r	1393 „	60.1	258.87
r'	1411 „	60.95	259.17
$\frac{r + r'}{4}$	720 „	62.2	518.33

The weakest current employed was capable of precipitating in 100 hours 130.74 milligrammes of silver. The equivalent amount of hydrogen is 1.2 milligrammes, or 13.42 cub. cent., which quantity would therefore have been liberated by the same current in 100 hours. This gas being somewhat soluble in water, as well as in acids and in solutions of salts, it is evident why the electrolysis of water by weak currents has escaped observation, and why some physicists have been led to believe that water can conduct small quantities of electricity without suffering decomposition.

In order to ascertain whether the decomposing power of weak currents is the same in different parts of the circuit, two cells filled with silver solution of the same composition were connected by the whole length of wire $r + r'$ with the constant battery. The current was passed with unvarying strength for nearly 9 days, or 12538 minutes. The following were the results :

1st. cell.	Loss of weight of the positive silver strip = 267	millgrms.
	Gain of weight of the negative silver strip = 266.6	„
2nd. „	Loss of weight of the positive silver strip = 267.6	„
	Gain of weight of the negative silver strip = 267.4	„

1 cub. cent. of the solution employed contained 25 milligrammes of neutral nitrate of silver.

To ascertain whether the state of concentration of the fluid had any influence, a more dilute solution was prepared, of which 1 cub. cent. contained 10 milligrammes of salt. Two cells filled with these solutions were introduced, together with the wire r , into the circuit. The experiment lasted 51.5 hours. After this time, the negative strip of silver in the stronger solution had gained 124.66 milligrammes in weight ; while the corresponding strip in the more dilute solution had

gained 124.16 milligrammes. The state of dilution has therefore no influence on the results of the electrolysis.

To obtain comparative results, it is necessary that the solutions should be perfectly pure.

Less silver is apparently deposited from acid solutions than is required by the law, and in alkaline solutions of cyanide of silver, some of the precipitated silver is also redissolved.

When the weakest current was employed, that is, when the whole length of wire $r+r'$ was included, the amount of silver dissolved in 10 hours was greater than that deposited. Acid solutions of sulphate of copper likewise yield, on galvanic decomposition, too little copper; this is caused by the simultaneous action of the atmospheric oxygen and of the free acid on the negative copper plate.

When a galvanic current was passed at the same time through a perfectly pure neutral solution of sulphate of copper, and through a solution of nitrate of silver, the results of the electrolysis of these two solutions showed a close coincidence in the metals deposited. The following are a few of the numbers obtained:

Duration of experiment in minutes.	Amount of silver in milligrammes.	Amount of copper:		Strength of current.
		Found.	Calculated.	
2669	107.4	33.9	31.44	1.85
1236	534.5	157.9	156.5	19.88
1397	683.85	200.6	200.2	22.5
1029	535.7	157.6	156.82	24.5
458	862.4	257.8	252.5	86.6

The strength of the current produced when the whole length of wire $r+r'$ was introduced, has been assumed as the unit of strength. After each experiment was ended, the copper was deposited on a strip of platinum, was freed from adhering sulphate by washing with boiled water, and then dried *in vacuo* over concentrated sulphuric acid. It was always covered with a thin coating of suboxide, from which it was freed by ignition in a current of hydrogen. In order to prevent this oxidation of the copper as much as possible during the experiment, the solution was previously freed from air. Some decompositions were effected entirely under the air-pump. During the experiment, hydrogen was frequently passed through the solution; none of these precautions were however quite effectual. Even that copper which had been ignited in hydrogen, and was consequently perfectly pure, soon became covered with a thin film of oxide, sometimes even during the time occupied in weighing.

The facility with which galvanically deposited copper absorbs oxygen from the air, is the reason why in all cases a little more copper was obtained than corresponds to the equivalent of silver.

It would scarcely be possible to prove the law of definite electrolytic action with other bodies capable of galvanic decomposition as readily as with copper- or silver-salts. I consider myself however justified in concluding, from the foregoing experiments, that wherever deviations from the law have been observed, they have been caused by local actions, which, however, it may not always be possible to obviate.

VII.—*Analytical Notes.*

By A. B. NORTHCOTE AND A. H. CHURCH.

1. *On the Action of Caustic Potash on the Phosphates.*

Experiments were undertaken on this subject with the view of discovering a better method than that generally adopted for estimating phosphoric acid,—the results obtained when the iron precipitate suspected to contain phosphoric acid is dissolved in hydrochloric acid, the solution treated with tartaric acid and ammonia, and subsequently, a salt of magnesia added to precipitate the phosphoric acid, being frequently found to give erroneous conclusions, because the tartaric acid solution often produces a precipitate in magnesia-salts, probably of ammonio-tartrate of magnesia, without a trace of phosphoric acid being present.

It has hitherto been supposed that the phosphate of sesquioxide of iron is but imperfectly attacked by solutions of the caustic alkalies, but the extent of the decomposition which can be thus effected had not been submitted to a careful experimental inquiry.

From the authors' experiments it appears that by boiling the precipitate of iron with a sufficient excess of potash, the phosphoric acid is completely transferred to the latter base; this method of proceeding is therefore recommended in the quantitative determination of phosphoric acid. It is proposed that the alkaline solution be deprived of alumina which might be introduced with the potash, by the addition of silicate of potash, and subsequently of excess of hydrochloric acid and ammonia. The filtered solution will then contain the whole of the phosphoric acid, which may be readily precipitated by a salt of magnesia.

2. *On the behaviour of some Oxides with Caustic Potash in the presence of Oxide of Chromium.*

The influence of the association of sesquioxide of chromium with metallic oxides, which by themselves are insoluble in solution of caustic potash, is well known; the insoluble oxides being, in some cases, rendered soluble when thus associated, while in the other cases, they communicate their insolubility to the otherwise soluble oxide of chromium.

The object of the inquiry instituted with reference to these results was to ascertain the exact conditions under which complete solution or precipitation of the associated oxides occurs. It was found that complete solution takes place when the chromium, as sesquioxide, is associated with 40 per cent of iron, as sesquioxide, with 12·5 per cent of manganese, 20 per cent of cobalt, or 25 per cent of nickel, as protoxides; and that complete precipitation takes place when the chromium, as sesquioxide, is associated with 80 per cent of iron, 60 per cent of manganese, 50 per cent of cobalt, or 50 per cent of nickel, as protoxide. When cobalt and nickel, however, are thus rendered soluble, the result is not permanent; and ultimately, not only does the oxide of cobalt or nickel become insoluble, but it carries down with it some of the oxide of chromium.

The other metallic oxides soluble in caustic potash were not found to be influenced in their relations with caustic potash by the presence of sesquioxide of iron, or to exert any influence upon that oxide.

PROCEEDINGS

AT THE

MEETINGS OF THE CHEMICAL SOCIETY.

January 17, 1853.

DR. DAUBENY, President, in the Chair.

John Carty, Esq., of Bond Street, was duly elected a Fellow of the Society.

Dr. Miller described a new form of Pipette for transferring gases.

Dr. H. Bence Jones explained a new process which he has recently proposed for dissolving Calculi in the Bladder through the agency of Electricity.

February 7, 1853.

COLONEL PHILIP YORKE, Vice-President, in the Chair.

The following donations were announced:

"Denkschriften der kaiserlichen Akademie der Wissenschaften:" Vol. III, Parts 1 and 3.

"Sitzungsberichte der kaiserlichen Akademie der Wissenschaften:" Vol. VII, Parts 3, 4, and 5; and Vol. VIII, Parts 1, 2 and 3: from the Imperial Academy of Vienna.

"Berichte über die Mittheilungen von Freunden der Naturwissenschaften in Wien;" von Wilhelm Haidinger: VIIter and letzter Band.

"Naturwissenschaftliche Abhandlungen, gesammelt und durch Subscription herausgegeben;" von Wilhelm Haidinger: Vol. IV, in 4 Parts: from the Author.

"Abhandlungen der mathemat.-physikalischen Classe der königlich-bayerischen Akademie der Wissenschaften," Vol. VI, Parts 2 and 3; from the Royal Academy of Bavaria.

"Ueber die Siedepunkte mehrerer alkoholhaltiger Flüssigkeiten und die darauf gegründeten Verfahren, &c.," von J. J. Pohl.

"Nachtrag zur thermo-aräometrischen Bierprobe," von J. J. Pohl.

"Beitrag zur Statistik des Studiums der Chemie am k. k. polytechnischen Institute zu Wien:" von J. J. Pohl.

"Physikalisch-chemische Notizen," von J. J. Pohl.

"Ueber die Zusammensetzung und Eigenschaften zweier Legierungen von Zinn und Blei," von J. J. Pohl.

"Ermittelung des technischen Werthes der Kartoffeln," von J. J. Pohl: from the Author.

"Barometrical Tables," by J. J. Pohl and J. Schabus.

"Calendar of the Flora of Prague during an observation of nearly ten years," by Karl Fritsch: from the Author.

"A new Theory of the Central Heat of the Earth, &c."

"On the Cause of the Phenomena exhibited by the Geysers of Iceland," and other pamphlets, by Stevenson Macadam: from the Author.

"Proceedings of the American Philosophical Society:" from the Society.

"The Journal of the Society of Arts:" from the Society.

Frank Clarke Hill, Esq., of the Chemical Works, Deptford;

Dr. Marcet, of 88, Cadogan Place; and J. J. Pohl, Esq., Professor of Applied Chemistry in the Polytechnic School of Vienna, were duly elected Fellows of the Society.

A paper was read:

“On the Mode of Estimating the Value of Red Prussiate of Potash, and of Testing the strength of Bleaching Liquors,” by Francis Lieshing.

February 21, 1853.

DR. DAUBENY, President, in the Chair.

Alfred Coleman, Esq., Bridgefield, Wandsworth; John Gotch Hepburn, L.L.B., Clapham; Stevenson Macadam, Esq., Philosophical Institution, Edinburgh; and George Foord, Esq., Melbourne, were duly elected Fellows of the Society.

The President declared the names of the Officers and other Members of Council proposed by the Council to retire from Office, and of the Officers and other Members of Council proposed to be substituted for them at the ensuing Anniversary Meeting.

Mr. John Arthur Phillips made a communication on the subject of Ancient Metallurgy.

March 7, 1853.

PROFESSOR GRAHAM in the Chair.

Alfred Coleman, Esq., was admitted a Fellow of the Society. William Crowder, Esq., 21, Northumberland Street, Newcastle-on-Tyne; Dr. William Charles Henry, F.R.S., of Hatfield, near Ledbury; and Christopher R. James, Esq., of Ebbw Vale Iron Works, Abergavenny, were duly elected Fellows of the Society.

Mr. Redwood made a communication on the Optical Properties of the Alkaloids found in the Cinchona Barks, and on some facts recently elicited relating to the History of Racemic Acid.

March 21, 1853.

DR. DAUBENY, President, in the Chair.

H. Pollock, Esq., of Queen Square House, Guildford Street, was duly elected a Fellow of the Society.

Dr. Williamson made a communication on the Atomic Theory.

NOTICES

OF

PAPERS CONTAINED IN OTHER JOURNALS.

On a new series of Organic Bodies containing Metals.

By Dr. E. Frankland.

(From the "Philosophical Transactions," abstracted by the Author.)

Under the above title, I described more than three years ago some preliminary experiments,* which proved the existence of certain organic compounds highly analogous to cacodyl, and like that body, consisting of a metal, or in some cases of phosphorus, associated with the groups C_2H_3 , C_4H_5 , &c., and possessing, in some instances, highly remarkable powers of combination. I fixed the composition, and studied some of the reactions of two of these bodies, to which the names zinc-methyl (C_2H_3Zn) and zinc-ethyl (C_4H_5Zn), were provisionally assigned, besides giving methods for procuring similar compounds containing tin, arsenic and phosphorus, by acting upon the iodides of the alcohol-radicals with these elements, and expressing a belief, founded upon the similarity of functions existing between hydrogen and the groups of the form $C_nH_{(n+1)}$, that most, if not the whole, of the compounds contained in the following series might be formed, those marked thus * being at that time already known.

Hydrogen series.	Methyl series.	Ethyl series.	Butyl series.	Valyl series.	Amyl series.	Phenyl series.
Zn H	Zn C_2H_3 *	Zn C_4H_5 *	Zn C_6H_7	Zn C_8H_9	Zn $C_{10}H_{11}$	Zn $C_{12}H_{13}$
As H_3 *	As $(C_2H_3)_2$ *	As $(C_4H_5)_2$	As $(C_6H_7)_2$	As $(C_8H_9)_2$	As $(C_{10}H_{11})_2$	As $(C_{12}H_{13})_2$
Sb H_3 *	Sb $(C_2H_3)_3$	Sb $(C_4H_5)_3$	Sb $(C_6H_7)_3$	Sb $(C_8H_9)_3$	Sb $(C_{10}H_{11})_3$	Sb $(C_{12}H_{13})_3$
P H_3 *	P $(C_2H_3)_3$ *	P $(C_4H_5)_3$	P $(C_6H_7)_3$	P $(C_8H_9)_3$	P $(C_{10}H_{11})_3$	P $(C_{12}H_{13})_3$

More recently, Löwig and Schweitzer† have commenced labour-

* Ann. Ch. Pharm. LXXI, 213; Chem. Soc. Qu. J. II, 297.

† Ann. Ch. Pharm. LXXV, 315.

ing in the same field, and have filled up one of the gaps in the foregoing table by the formation of stibethyl, $\text{Sb}(\text{C}_4\text{H}_5)_3$, by acting upon iodide of ethyl with an alloy of antimony and potassium. The same chemists state, also, the probable formation of similar compounds containing methyl and amyl in the place of ethyl, and bismuth and phosphorus instead of antimony.

The agents which I have employed in the formation of these organo-metallic bodies are two—viz. : heat and light ; in many cases, either of these can be used, in others, only one can be made to effect the desired combination, whilst more rarely the assistance of both appears to be essential. In those experiments in which heat was employed, the materials were subjected to its action in sealed glass tubes, about 12 inches long, and varying in diameter from $\frac{1}{2}$ inch to 1 inch, the thickness of the glass being about $\frac{1}{8}$ inch. To preserve the gaseous products of the operation in a state of perfect purity for subsequent investigation, the tubes were well exhausted before being sealed ; they were then immersed to about half their depth in an oil-bath, and heated to the required temperature. In cases where the influence of light was employed, the materials, confined in tubes of precisely similar dimensions, were exposed to the sun's rays, concentrated in most instances by an 18-inch parabolic reflector, near the focus of which the tubes were placed, either naked, or surrounded by a solution of sulphate of copper, to absorb the calorific rays. By this arrangement, the light and heat could be increased, diminished, or modified, at pleasure, which was found very convenient in several of the operations.

ACTION OF TIN UPON IODIDE OF ETHYL.

When iodide of ethyl and metallic tin are exposed to the action of either heat or light, the tin gradually dissolves in the ethereal liquid, which finally solidifies to a mass of nearly colourless crystals. This reaction is effected most conveniently by the action of light, an excess of tin-foil, cut into narrow strips, being employed. The sealed tubes containing these ingredients should be placed near the focus of a large parabolic reflector, the temperature being prevented, if necessary, from rising too high, by immersing them in water, or in a solution of sulphate of copper. The unconcentrated rays of the sun, or even diffused daylight, are quite sufficient to determine the formation of the crystalline body ; but an exposure of several weeks, or even months, would be necessary for the completion of the change which is effected by the use of the reflector in a few days of bright sunshine. The liquid gradually assumes a straw-yellow colour, but its solidification is prevented as long as possible at the close of the operation, by allowing the temperature to rise to 35° , or 40° C. ; thus nearly the whole of the iodide of ethyl becomes

united with tin. When heat instead of light is employed to effect the combination, the tubes should not be more than $\frac{1}{2}$ inch in diameter, and to avoid the risk of explosion, should only be one-fourth filled with the materials: the combination takes place at about 180° C. The agency of heat is, therefore, much less convenient than that of light in the production of this reaction, which is also never so complete as when the latter agent is employed. I have, however, satisfied myself that the results are the same in both cases.

I. *Examination of Solid Products*.—The capillary extremities of the tubes in which the foregoing reaction has taken place were broken off, under sulphuretted water, and beneath a jar filled with the same liquid:* the gases evolved were preserved for eudiometrical investigation. The crystalline product was then withdrawn from the tubes, and after being exposed to a gentle heat for a few minutes, to expel the iodide of ethyl that had escaped combination, was treated with alcohol, in which the crystals readily dissolved, leaving only a small residue of a bright red colour, which proved to be protoiodide of tin. The filtered alcoholic solution was then placed over sulphuric acid *in vacuo*, where it soon deposited a large crop of long, needle-like crystals, which, when freed from the mother-liquor, washed with a small quantity of dilute alcohol, dried between folds of bibulous-paper, and, finally, over sulphuric acid *in vacuo*, yielded analytical results corresponding closely with the formula:



This body is, therefore, the iodide of a new organo-metallic radical, for which I propose the name, STANETHYLIUM.

Iodide of Stanethylum crystallizes in transparent, slightly straw-coloured needles, which are right-rectangular prisms, frequently $\frac{1}{12}$ inch broad, and 2 or 3 inches in length. They are very soluble in ether and in boiling alcohol, less so in cold alcohol and in water; the watery solution is decomposed on boiling, oxide of stanethylum being precipitated, and hydriodic acid formed. Iodide of stanethylum fuses at 42° C., and boils at 240° C., undergoing, at the same time, partial decomposition; it possesses at common temperatures a peculiar pungent odour, somewhat resembling the volatile oil of mustard, and which irritates the eyes and lining membrane of the nose, causing a discharge, which continues for several hours, or even days, especially if the vapour from the heated iodide of stanethylum be inhaled; yet this compound can scarcely be said to be volatile at common temperatures, since a few grains may be exposed to the air for several weeks without any appreciable loss of weight.

Oxide of Stanethylum.—In contact with solutions of the alkalies, iodide of stanethylum is immediately decomposed, oxide of stanethylum and an alkaline iodide being formed:

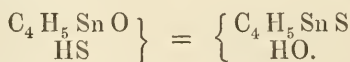
* Chem. Soc. Qu. J. II, 267.



With solutions of potash and soda, the oxide of stanethylium dissolves in an excess of the precipitant, but is reprecipitated, unchanged, by cautious neutralization. The precipitated oxide is almost completely insoluble in an excess of ammonia. A quantity of the oxide of stanethylium, prepared by precipitation with an excess of ammonia, and submitted to analysis, yielded results agreeing with the above formula.

Oxide of stanethylium presents the appearance of a somewhat cream-white amorphous powder, closely resembling peroxide of tin, but less heavy than that oxide; it has a peculiar, though slight ethereal odour, and a bitter taste; it is insoluble in water, alcohol and ether, but readily dissolves in solutions of the acids, and of the fixed alkalies; with acids it forms salts, which are, however, for the most part difficultly crystallizable; those with strong acids exhibit an acid reaction. The nitrate deflagrates when heated to about 120°C. , and on the application of a higher heat becomes pure peroxide of tin. The salts of the oxide of stanethylium behave with reagents so nearly like the salts of peroxide of tin, that the two are very difficult to distinguish from each other.

Sulphide of Stanethylium.—When sulphuretted hydrogen is passed through an acid solution of a salt of stanethylium, a cream-coloured precipitate falls, which is insoluble in dilute acids and ammonia, but soluble in concentrated hydrochloric acid, solutions of the fixed alkalies and alkaline sulphides; from its solutions in the fixed alkalies and alkaline sulphides it is reprecipitated unchanged on the addition of an acid. Its formula is $\text{C}_4 \text{H}_5 \text{Sn S}$, and it is produced by the following reaction:

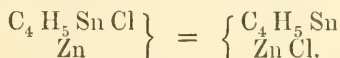


Sulphide of stanethylium presents the appearance of an amorphous cream-coloured powder, having a pungent and very nauseous smell, resembling that of decaying horseradish; when heated it fuses, froths up and decomposes, emitting vapours of a most insupportable odour. Heated with nitric acid it is decomposed, with the formation of peroxide of tin.

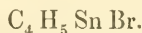
Chloride of Stanethylium, $\text{C}_4 \text{H}_5 \text{Sn Cl}$.—This salt is best prepared by dissolving oxide of stanethylium in dilute hydrochloric acid; on evaporation at a gentle heat or over sulphuric acid *in vacuo*, the chloride crystallizes out in long colourless needles, isomorphous with the iodide, which salt it also closely resembles in all its properties; it is, however, more volatile, and therefore emits a more intensely pungent and irritating odour than the iodide.

Stanethylium.—When a strip of zinc is immersed in a solution of

a salt of stanethylium (a solution of the chloride of stanethylium is the best for this purpose), it speedily becomes covered with dense oily drops of a yellow colour, which finally separate from the lower extremity of the zinc, and accumulate at the bottom of the vessel; the formation of the oily liquid is much favoured by gentle heat. The yellow oil, well washed with water, dried over chloride of calcium, and submitted to analysis, yielded results agreeing with the formula C_4H_5Sn , and showing that stanethylium is formed by the following simple reaction :



Stanethylium is a thick, heavy, oily liquid, of a yellow or brownish-yellow colour and an exceedingly pungent odour, resembling that of its compounds, but much more powerful. It is insoluble in water, but soluble in alcohol and ether. At about $150^\circ C$. it enters into ebullition, a quantity of metallic tin is deposited, and a colourless liquid distils over, having a peculiar odour, containing a considerable quantity of tin and exhibiting no tendency to combine with iodine or bromine. I have not yet further examined this liquid; but it possibly consists of, or contains, *binethide of tin*, $Sn(C_4H_5)_2$. In contact with air, stanethylium rapidly attracts oxygen, and is converted into a white powder, which has all the properties of oxide of stanethylium. Chloride, iodide and bromide of stanethylium, are instantaneously formed by the action of chlorine, iodine and bromine, or their hydrogen acids, respectively, upon stanethylium; the two first are in every respect identical with the salts above described, and the bromide, which closely resembles them, yielded analytical results in harmony with the formula



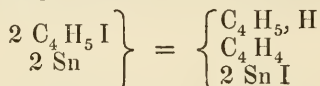
Thus, stanethylium perfectly resembles cacodyl in its reactions, combining directly with the electro-negative elements, and regenerating the compounds from which it has been derived.

II. *Examination of Gaseous Products.*—The examination of the gases evolved on opening the tubes in which iodide of ethyl and tin had been exposed to the action of heat or light, showed that they consisted of hydride of ethyl and olefiant gas, in proportions indicated by the following percentage numbers :

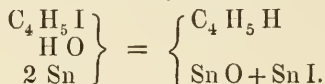
	I. and II.	III.
Hydride of Ethyl. . . .	81.61	81.43
Olefiant gas	16.82	17.28
Nitrogen	1.57	1.29
	100.00	100.00

The presence of hydride of ethyl and olefiant gas, amongst the

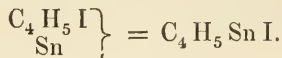
products of the action of heat, or light, upon iodide of ethyl and tin, shows that the direct combination of these latter bodies is not the only reaction which takes place, but that a portion of the iodide of ethyl is also decomposed by the tin, with the production of iodide of tin and ethyl, the latter body being transformed, at the moment of its liberation, into hydride of ethyl and olefiant gas, a catalysis to which this radical is so prone.



The large excess of hydride of ethyl exhibited in the above analytical results, may have been caused, either by the greater solubility of olefiant gas in iodide of ethyl (a further and considerable amount of gas being expelled from the tubes by a gentle heat), or by the presence of moisture in the materials, which would give rise to the formation of oxyiodide of tin and hydride of ethyl.



Both these causes probably contributed to produce the excess of hydride of ethyl; but the very small amount of gaseous products compared with the solid ones, shows that the production of the former is only an accidental circumstance, which, however it may be interpreted, does not at all affect the principal reaction—viz.: the formation of iodide of stanethylum.



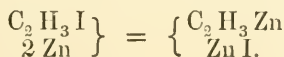
STANMETHYLUM and STANAMYLUM, are formed when the iodides of methyl and amyl, respectively, are exposed to the action of light in contact with tin. Their salts are isomorphous with those of stanethylum; but I have not completed the investigation of these bodies.

ACTION OF ZINC UPON IODIDE OF METHYL.

When iodide of methyl and zinc are exposed to a temperature of about 150° C., in a sealed tube, the zinc gradually dissolves, with the evolution of gas, whilst a mass of white crystals, and a colourless mobile liquid occupy, after a few hours, the place of the original materials. The gas evolved on breaking off the capillary extremity of the previously exhausted tube, was collected and preserved over sulphuretted water. I will refer to this gas again, under the name of α . On cutting off the upper portion of the tube, and pouring cold distilled water upon the mobile liquid and white mass of crystals just mentioned, a very violent action ensued, and a column of flame,

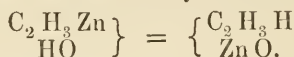
several feet high, shot up momentarily from the mouth of the tube; but the action soon became more moderate, and a cork and gas-delivering tube being fitted into the decomposition-tube, the gas was collected and preserved. I will call this second gas β .

ZINCMETHYLIUM.—From a preliminary experiment, it was ascertained that the gas evolved on opening the decomposition-tube possessed, before contact with water, a most insupportable and very peculiar odour, and that when ignited it burnt with a greenish-blue flame, producing dense white fumes; when a porcelain plate was held in this flame, it immediately became coated with a jet-black deposit, surrounded with a white ring; this black deposit dissolved in dilute hydrochloric acid, with evolution of hydrogen gas, and the solution was found to contain chloride of zinc. Hence, it was evident that a gaseous, or volatile compound of zinc, was present amongst the products of decomposition, and this was soon found to reside in the mobile liquid above mentioned; for on inverting the tube, and allowing a few drops of the liquid to escape, it inflamed spontaneously the instant it came in contact with the air, and produced by its combustion large quantities of oxide of zinc. In order to obtain this liquid in a state of purity, another tube was charged with iodide of methyl and excess of zinc, and subjected to a heat of 150° to 160° C., until every trace of iodide of methyl was decomposed. The drawn-out extremity of the tube being broken off, the included gas was allowed to escape, and the liquid contents were then separated from the solid ones by distillation at a gentle heat, in an atmosphere of dry hydrogen. The analytical operations upon this liquid proved it to be a new radical, for which zinemethylum (C_2H_3Zn) will be a convenient name, and that it is formed by the following reaction:



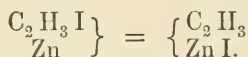
Zinemethylum is a colourless, transparent and very mobile liquid, refracting light strongly, and possessing a peculiar, penetrating and insupportable odour; it is very volatile, but I have not yet been able to determine its boiling-point with accuracy. Zinemethylum combines directly with oxygen, chlorine, iodine, &c., forming somewhat unstable compounds, a description of which I reserve for a future communication. Its affinity for oxygen is even more intense than that of potassium; in contact with atmospheric air it instantaneously ignites, burning with a beautiful greenish-blue flame, and forming white clouds of oxide of zinc; in contact with pure oxygen, it burns with explosion, and the presence of a small quantity of its vapour in combustible gases, gives them the property of spontaneous inflammability in oxygen. Thrown into water, zinemethylum decomposes that liquid with explosive violence, and with the evolution of heat

and light; when the action is moderated, the sole products of the decomposition are oxide of zinc and hydride of methyl.



The extraordinary affinity of zincmethylum for oxygen and electro-negative elements in general, its peculiar composition, and the facility with which it can be procured, cannot fail to cause its employment for a great variety of transformations in organic compounds. By its agency, there is every probability that we shall be able to replace oxygen, chlorine, &c., atom for atom, by methyl, and thus, produce an entirely new series of organic compounds, and obtain clearer views of the constitution of others. I intend to pursue this branch of the subject whilst studying the compounds of zincmethylum, and the corresponding bodies containing ethyl and amyl.

An examination of the gas α , proved it to consist of equal volumes of methyl (C_2H_3), and hydride of methyl ($\text{C}_2\text{H}_3\text{H}$): no trace of the first term of the olefiant gas series (C_2H_2) was present, although the analogous decomposition of the iodides of ethyl and amyl by zinc,* led me to search very carefully for it. The occurrence of methyl amongst the products of the decomposition shows that a portion of the iodide of methyl is decomposed, according to the following equation:



The origin of the hydride of methyl is readily perceived, when the volatility of zincmethylum, and the method of collecting the gas, are taken into consideration. On opening the decomposition-tube beneath water, a copious effervescence was observed wherever the evolved gas came in contact with water; and as this effervescence was accompanied by the formation of a flocculent precipitate of oxide of zinc, it could only be caused by the presence of the vapour of zincmethylum, which, on coming in contact with water, would be instantaneously decomposed into oxide of zinc and hydride of methyl.

The gas β , evolved by the action of water upon the solid and liquid products of the decomposition, was found, as might have been anticipated, to be pure hydride of methyl, derived from the decomposition of the zincmethylum, with which the crystalline residue of iodide of zinc was saturated.

ZINCETHYLUM ($\text{C}_4\text{H}_5\text{Zn}$) and ZINCAMYLUM ($\text{C}_{10}\text{H}_{11}\text{Zn}$), are formed under precisely similar circumstances, the iodides of ethyl and amyl being respectively substituted for iodide of methyl. They are colourless and transparent liquids, refracting light strongly, and

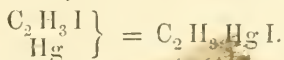
* Chem. Soc. Qu. J. II, 265; III, 30.

possessing a peculiar penetrating odour. They are less volatile than zinemethylum, and are also somewhat weaker in their powers of combination. They unite directly with oxygen, chlorine, &c., and are decomposed in contact with water in a manner perfectly analogous to zinemethylum, producing oxide of zinc, and the hydrides of ethyl and amyl, respectively.

ACTION OF MERCURY UPON IODIDE OF METHYL.

When iodide of methyl is exposed to sunlight, in contact with metallic mercury, it soon becomes coloured red, from the separation of free iodine; after several hours' exposure, this coloration disappears, and a small quantity of the yellow iodide of mercury subsides to the bottom of the liquid. After the action of sunlight for several days, the bulk of the mercury is observed to have considerably diminished; white crystals begin to be deposited around the sides of the glass vessel; and, finally, after about a week's exposure, the liquid solidifies to a colourless, crystalline mass; when this is digested with ether, the new compound dissolves, and is thus separated from metallic mercury and a small quantity of iodide of mercury, which is collaterally formed. Only a very small quantity of gas is evolved during the formation of this white crystalline compound. By spontaneous evaporation, the ethereal solution solidifies to a mass of minute, colourless, crystalline scales; these, dried *in vacuo*, and submitted to analysis, yielded results closely corresponding with the formula $C_2 H_3 Hg I$.

This compound is, therefore, evidently the iodide of a new organo-metallic radical, consisting of one atom of methyl and one atom of mercury, and for which I propose the name **HYDRARGYROMETHYLUM**: its iodide is formed by the direct union of one atom of mercury with one atom of iodide of methyl, under the influence of light.



Iodide of hydrargyromethylum is a white solid, crystallizing in minute nacreous scales, which are insoluble in water, moderately soluble in alcohol, and very soluble in ether and iodide of methyl; by the spontaneous evaporation of these solutions, the crystals are again deposited unchanged. Iodide of hydrargyromethylum is slightly volatile at ordinary temperatures, and exhales a slight, but peculiarly unpleasant odour, which leaves a nauseous taste upon the palate for several days; at $100^\circ C$. the volatility is much greater, and the crystals are rapidly dissipated at this temperature, when exposed to a current of air. At $143^\circ C$. it fuses, and sublimes without decomposition, condensing in brilliant and extremely thin crystalline plates. In contact with solutions of the fixed alkalies and ammonia,

it is converted into oxide of hydrargyromethylum, which is dissolved in excess of all these reagents; from these solutions, sulphide of ammonium throws down sulphide of hydrargyromethylum as a slightly yellow, flocculent precipitate, having a most insupportable odour. I have not yet further examined the reactions of this remarkable body, nor have I attempted the isolation of the hydrargyromethylum.

A corresponding compound containing amyl is formed, though with difficulty, under similar circumstances; but I have not yet succeeded in producing one containing ethyl, the iodide of this radical yielding, as I have shown,* when exposed to sunlight in contact with mercury, iodide of mercury, and a mixture of ethyl, hydride of ethyl and olefiant gases.

I have also made some preliminary experiments with other metals, and find that most of them are capable of thus entering into combination with the organic groups, methyl, ethyl and amyl: amongst those which thus combine under the influence of light most readily, and seem to promise the most interesting results, I may mention, arsenic, antimony, chromium, iron, manganese and cadmium.

Imperfect as our knowledge of the organo-metallic bodies may yet appear, I am unwilling to close this memoir without directing attention to some peculiarities in the habits of these compounds, which promise, at least, to throw some light upon their rational constitution, if they do not lead to extensive modifications of our views respecting chemical compounds in general, and especially that interesting class termed conjugate compounds.

That stanethylum, zincmethylum, hydrargyromethylum, &c., are perfectly analogous to cacodyl, there can be no reasonable doubt, inasmuch as, like that body, they combine directly with the electro-negative metalloids, forming true salts, from which in most cases, and probably in all, the original groups can be again separated unaltered; and, therefore, any view which may be taken of the new bodies must necessarily be extended to cacodyl. The discovery and isolation of this so-called organic radical by Bunsen, was certainly one of the most important steps in the development of organic chemistry, and one, the influence of which upon our theoretical views of the constitution of certain classes of organic compounds, can scarcely be too highly estimated. It was impossible to consider the striking features in the behaviour of this body, without finding in them a most remarkable confirmation of the theory of compound radicals, as propounded by Berzelius and Liebig.

The formation of cacodyl, its habits, and the products of its

* Chem. Soc. Qu. J. III, 331.

decomposition, have for some time left no doubt of the existence of methyl readily formed in this body; and Kolbe,* in developing his views on the so-called conjugate compounds, has proposed to regard it as arsenic conjugated with two atoms of methyl, $(C_2H_3)_2 As$. So long as cacodyl was an isolated example of an organo-metallic body, this view of its rational composition, harmonizing as it did so well with the facts elicited during the route of cacodyl through its various combinations and decompositions, could scarcely be contested; but now, since we have become acquainted with the properties and reactions of a considerable number of analogous bodies, circumstances arise which I consider militate greatly against this view, if they do not render it absolutely untenable. According to the theory of conjugate radicals just alluded to, cacodyl and its congeners, so far as they are at present known, would be thus represented:

Cacodyl	.	.	.	.	$(C_2 H_3)_2 \text{As}$
Oxide of cacodyl	.	.	.	.	$(C_2 H_3)_2 \text{AsO}$
Cacodylic acid	.	.	.	.	$(C_2 H_3)_2 \text{AsO}_3$
Stannemethylum	.	.	.	.	$(C_2 H_3)_2 \text{Sn}$
Stannethylum	.	.	.	.	$(C_4 H_5)_2 \text{Sn}$
Oxide of stannethylum	.	.	.	.	$(C_4 H_5)_2 \text{SnO}$
Stannamylum	.	.	.	.	$(C_{10} H_{11})_2 \text{Sn}$
Zincemethylum	.	.	.	.	$(C_2 H_3)_2 \text{Zn}$
Zincethylum	.	.	.	.	$(C_4 H_5)_2 \text{Zn}$
Zincamylum	.	.	.	.	$(C_{10} H_{11})_2 \text{Zn}$
Stibethine (Stibethyl)	.	.	.	.	$(C_4 H_5)_3 \text{Sb}$
Binoxide of stibethine	.	.	.	.	$(C_4 H_5)_3 \text{SbO}_2$
Oxide of stibemethylum	.	.	.	.	$(C_2 H_3)_4 \text{SbO}$
Hydrargyromethylum	.	.	.	.	$(C_2 H_3)_2 \text{Hg}$
Iodide of hydrargyromethylum	.	.	.	.	$(C_2 H_3)_2 \text{HgI}$

It is generally admitted, that when a body becomes conjugated, its essential chemical character is not altered by the presence of the conjunct; thus, the series of acids $C_n H_n O_4$, formed by the conjunction of the radicals $C_n H_{(n+1)}$ with oxalic acid, have the same neutralizing power as the original oxalic acid, and, therefore, if we assume the organo-metallic bodies to be metals conjugated with various hydrocarbons, we might reasonably expect that the chemical relations of the metal to oxygen, chlorine, sulphur, &c., would remain unchanged. A glance at the formulæ of these compounds will, however, suffice to show that this is far from being the case. It is true, that cacodyl forms protoxide of cacodyl and cacodylic acid, corresponding, the one, to a somewhat hypothetical protoxide of arsenic, which, if it exist, does not seem to possess any well-defined

* Chem. Soc. Qu. J. III, 372.

basic character, and the other, to arsenious acid; but no compound corresponding to arsenic acid can be formed; and yet it cannot be urged that cacodylic acid is decomposed by the powerful reagents requisite to produce further oxidation, for concentrated nitric acid may be distilled from cacodylic acid without decomposition or oxidation, in the slightest degree. The same anomaly presents itself even more strikingly in the case of stanmethylum, which, if we are to regard it as a conjugate radical, ought to combine with oxygen in two proportions at least, to form compounds corresponding to protoxide and peroxide of tin. Stanethylum rapidly oxidizes when exposed to the air, and is converted into pure protoxide; but this compound exhibits none of that powerful tendency to combine with an additional equivalent of oxygen, which is so characteristic of protoxide of tin; nay, it may even be boiled with dilute nitric acid, without evincing any signs of oxidation. I have been quite unable to form any higher oxide than that described above: it is only when the group is entirely broken up, and the ethyl separated, that the tin can be induced to unite with another equivalent of oxygen. Stibethyl also refuses to unite with more or less than two equivalents of oxygen, sulphur, iodine, &c., and thus forms compounds, which are not at all represented amongst the combinations of the simple metal, antimony.

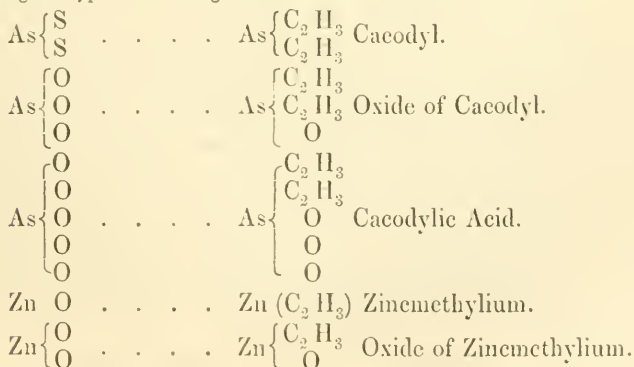
When the formulæ of inorganic chemical compounds are considered, even a superficial observer is struck with the great symmetry of their construction; the compounds of nitrogen, phosphorus, antimony and arsenic especially exhibit the tendency of these elements to form compounds containing three or five equivalents of other elements, and it is in these proportions that their affinities are best satisfied; thus in the ternary group we have NO_3 , NH_3 , NI_3 , NS_3 , PO_3 , PH_3 , PCl_3 , SbO_3 , SbH_3 , SbCl_3 , AsO_3 , AsH_3 , AsCl_3 , &c., and in the five-atom group NO_5 , NH_4O , NH_4I , PO_5 , PH_4I , &c. Without offering any hypothesis regarding the cause of this symmetrical grouping of atoms, it is sufficiently evident, from the examples just given, that such a tendency or law prevails, and that, no matter what the character of the uniting atoms may be, the combining power of the attracting element, if I may be allowed the term, is always satisfied by the same number of these atoms. It was probably a glimpse of the operation of this law amongst the more complex organic groups which led Laurent and Dumas to the enunciation of the theory of types; and had not those distinguished chemists extended their views beyond the point to which they were well supported by then existing facts, had they not assumed that the properties of an organic compound are dependant upon the position, and not upon the nature of its single atoms, that theory would undoubtedly have contributed to the development of the science to a still greater extent than it has already done. Such an assumption could only have been made at a time

when the data upon which it was founded were few and imperfect, and as the study of the phenomena of substitution progressed it gradually become untenable, and the fundamental principles of the electro-chemical theory again assumed their sway. The formation and examination of the organo-metallic bodies promises to assist in effecting a fusion of the two theories which have so long divided the opinions of chemists, and which have too hastily been conceived irreconcilable; for whilst it is evident that certain types of series of compounds exist, it is equally clear that the nature of the body derived from the original type is essentially dependent upon the electro-chemical character of its chemical atoms, and not merely upon the relative position of those atoms. Let us examine, for instance, the compounds formed by zinc and antimony: by combination with one equivalent of oxygen, the electro-negative quality of the zinc is nearly annihilated, and it is only by the highly oxidizing peroxide of hydrogen that the metal can be made to form a very instable peroxide; but when zinc combines with one equivalent of methyl or ethyl, its positive quality, so far from being neutralized, is exalted by the addition of the positive group, and the compound now exhibits such intense affinity for the electro-negative elements as to give it the property of spontaneous inflammability. Peroxide of antimony has also little tendency to pass into a higher state of oxidation; but when its three atoms of oxygen are replaced by the electro-positive ethyl, as in stibethine, that affinity is elevated to the intense degree which is so remarkable in this body.

Taking this view of the so-called conjugate organic radicals, and regarding the oxygen, sulphur and chlorine compounds of each metal as the true molecular type of the organo-metallic bodies derived from it by the substitution of an organic group for oxygen, sulphur, &c., the anomalies above mentioned entirely disappear, and we have the following inorganic types and organo-metallic derivatives:

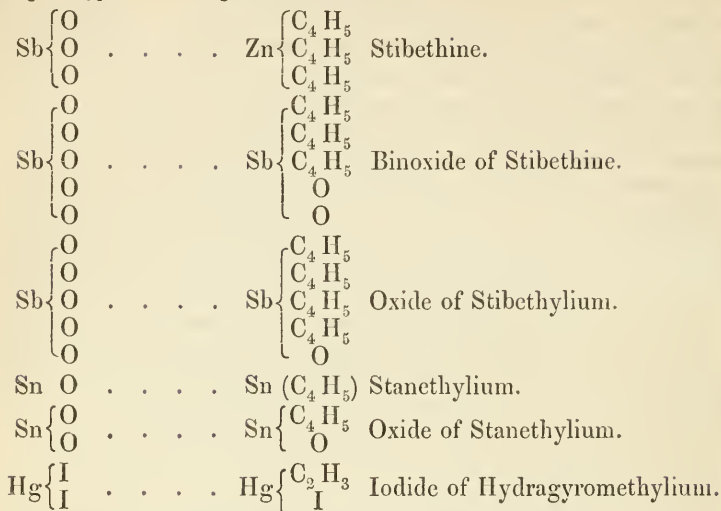
Inorganic types.

Organo-metallic derivatives.



Inorganic types.

Organo-metallic derivatives.



The only compound which does not harmonize with this view is ethostibilic acid, to which Löwig assigns the formula $\text{C}_4\text{H}_5\text{SbO}_5$; but as that chemist has not yet fully investigated this compound, it is possible that further research may satisfactorily elucidate its apparently anomalous composition.

It is obvious that the establishment of this view of the constitution of the organo-metallic bodies will remove them from the class of organic radicals and place them in intimate connection with ammonia and the bases of Wurtz, Hofmann, and Paul Thenard; indeed the close analogy existing between stibethine and ammonia, first suggested by Gerhardt, has been most satisfactorily demonstrated by the behaviour of stibethine with the haloid compounds of methyl and ethyl. Stibethine furnishes us therefore with a remarkable example of the law of symmetrical combination above alluded to, and shows that the formation of a five-atom group from one containing three atoms can be effected by the assimilation of two atoms, either of the same or of opposite electro-chemical character; this remarkable circumstance suggests the following question. Is this behaviour common also to the corresponding compounds of arsenic, phosphorus, and nitrogen; and can the position of each of the five atoms, with which these elements respectively combine, be occupied indifferently by an electro-negative or an electro-positive element? This question, so important for the advance of our knowledge of the organic bases and their congeners, cannot now long remain unanswered.

If the views which I have just ventured to suggest should be as

well supported by future researches as they are by the facts already known, they must occasion a profound change in the nomenclature of the extensive series of compounds affected by them. I have not, however, ventured to introduce this new system of nomenclature even in the case of the new bodies described in this memoir; since hasty changes of this kind, unless absolutely necessary, are always to be deplored. In accordance with the suggested view of the constitution of the organo-metallic compounds, the following plan of nomenclature would probably be found most convenient.

ARSENIC COMPOUNDS.

$(C_2 H_3)_2 As$	. .	Bimethide of Arsenic (Cacodyl).
$(C_2 H_3)_2 AsO$	. .	Bimethoxide of Arsenic (Oxide of Cacodyl).
$(C_2 H_3)_2 AsO_3$	. .	Bimetharsenic Acid (Cacodylic Acid).

ZINC COMPOUNDS.

$(C_2 H_3) Zn$	. .	Methide of Zinc (Zincmethylum).
$(C_4 H_5) Zn$	. .	Ethide of Zinc (Zincethylum).
$(C_{10} H_{11}) Zn$	. .	Amylide of Zinc (Zincamylium).

TIN COMPOUNDS.

$(C_2 H_3) Sn$	. .	Methide of Tin (Stanmethylum).
$(C_2 H_3) SnI$	. .	Methiodide of Tin (Iodide of Stanmethylum).
$(C_4 H_5) SnO$	. .	Ethoxide of Tin (Oxide of Stanethylum).
$(C_{10} H_{11}) SnCl$	. .	Amylochloride of Tin (Chloride of Stanamylium).

ANTIMONY COMPOUNDS.

$(C_2 H_3)_3 Sb$	. .	Termethide of Antimony (Stibmethine).
$(C_2 H_3)_4 SbO$	. .	Quadromethoxide of Antimony (Oxide of Stibmethylum).
$(C_4 H_5)_3 SbO_2$	. .	Terethobinoxide of Antimony (Binoxide of Stibethine).

MERCURY COMPOUNDS.

$(C_2 H_3) Hg$	. .	Methide of Mercury (Hydrargyromethylum).
$(C_2 H_3) HgI$	. .	Methiodide of Mercury (Iodide of Hydrargyromethylum).

In naming the new bodies described in the present paper, I have, in conformity with the nomenclature of the organic bases, adopted the principle of employing the termination "*ium*," when the body unites with one equivalent of oxygen, chlorine, &c., like ammonium, and the terminal "*ine*," when like ammonia it combines with two additional atoms.

On Meconic Acid and its Derivatives.

By Henry How.*

This investigation was undertaken with the view of determining whether compounds analogous to those already described by the author† as derived from comenic acid, could be obtained under similar circumstances from meconic acid.

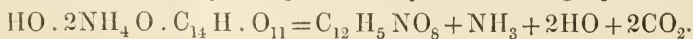
To obtain pure meconic acid, the crude acid—prepared by treating meconate of lime three times in succession with 20 parts of boiling water and 3 parts of strong hydrochloric acid—is mixed with about twice its weight of water, and heated over the water-bath with constant agitation, and caustic ammonia added till the whole is dissolved; the ammoniacal salt thus formed is very soluble in boiling water, and solidifies on cooling. The solid mass is subjected to strong pressure to remove the mother-liquid, and purified by three crystallizations from the smallest possible quantity of boiling water, the mother-liquor being expressed at each crystallization. The product is a perfectly white salt, from the solution of which in hot water, the meconic acid may be separated by hydrochloric acid in colourless shining laminae; and on washing the precipitate a little with cold water, and dissolving in the smallest possible quantity of boiling water, the solution on cooling yields the acid in a state of perfect purity.

Bibasic Meconate of Ammonia.—The salt whose preparation has just been described, crystallizes from moderately dilute solutions, after standing, in radiated groups of fine silky needles, having an acid reaction. The salt dried at 100° has the composition :



It is very hygroscopic. The crystals appear to contain variable quantities of water of crystallization. An aqueous solution of this salt may be boiled without change; but when kept boiling for some time with an excess of ammonia, it becomes altered.

Action of Heat on Meconate of Ammonia.—Comenamic Acid.—Some of the highly coloured mother-liquors of the purifying process were retained at or near the boiling temperature, ammonia being present in excess, and hydrochloric acid added after cooling. Carbonic acid was then copiously evolved, and a considerable precipitate formed, consisting of comenamic acid, $\text{C}_{12}\text{H}_5\text{NO}_8$, which, by repeated crystallization from boiling water, and the use of animal charcoal, was obtained in colourless shining scales. Its formation from bibasic meconate of ammonia may be represented by the following equation :



* Edinb. Phil. Trans. XX, Pt. III, 401; Ann. Ch. Pharm. LXXXIII, 350.

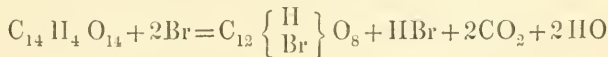
† Chem. Soc. Qu. J. IV, 362.

This reaction offers a convenient source of comenamic acid, as very impure meconic acid may be used.

Action of Chlorine on Bibasic Meconate of Ammonia.—Chlorine passed through the coloured mother-liquor deprives it of colour considerably, and causes a deposit of hard granular crystals, which may be purified by recrystallization from boiling water. Hard crystals are then deposited, which when magnified appear to consist of thick needles radiating from a centre. The salt thus formed contains no chlorine, but is a *monobasic meconate of ammonia*, $2\text{HO} \cdot \text{NH}_4\text{O} \cdot \text{C}_{14}\text{H}_{11}\text{O}_8$. The crystals likewise contain 7.70 per cent of water of crystallization = $2\Delta\text{q}$.

The original mother-liquor of this salt deposited a further quantity of the same on being concentrated, but by continued evaporation crystals of a different character were obtained; and these, when recrystallized from boiling water, presented themselves in the form of square prismatic needles, having the properties and composition of *chlorocomenic acid*, $2\text{HO} \cdot \text{C}_{12} \left\{ \begin{smallmatrix} \text{H} \\ \text{Cl} \end{smallmatrix} \right\} \text{O}_8$. The last mother-liquors of this process contain oxalic acid.

Action of Bromine on Meconic Acid.—When bromine-water is poured upon powdered meconic acid, carbonic acid is evolved with lively effervescence, and the acid dissolves, forming a solution which, after a while, deposits long prismatic crystals of great beauty; a much more copious product is however obtained by gentle evaporation. By recrystallization from hot water, brilliant square prismatic crystals are obtained, which when dried at 100°C . have the composition of dry bromocomenic acid, $2\text{HO} \cdot \text{C}_{12} \left\{ \begin{smallmatrix} \text{H} \\ \text{Br} \end{smallmatrix} \right\} \text{O}_8$. The nature of the reaction is shown by the equation:



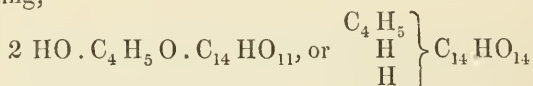
Crystals of oxalic acid were obtained by evaporating the mother-liquors to a small bulk.

The action of bromine on meconate of ammonia would doubtless be found similar to that of chlorine.

ETHERS OF MECONIC ACID.—When a current of dry hydrochloric acid gas is passed through an alcoholic solution of meconic acid till it fumes strongly, and the liquid is set aside to cool, there appears, after a time, shorter or longer as the alcohol is stronger or weaker, a deposit of feathery crystals. If absolute alcohol has been used, the filtered liquid yields no further deposit; but if rectified spirit has been used, another less crystalline substance appears after a time.

On evaporating the liquid which has ceased to give deposits, to complete dryness, the chief constituent of the residue is found to be a substance which fuses under boiling water. It is more or less accompanied by the other bodies, according to the strength of the alcohol used.

Ethylomeconic Acid.—This is the first deposit above mentioned; it is formed most abundantly and in the state of greatest purity when absolute alcohol is used. One crystallization from hot water is sufficient to render it perfectly pure and uniform, and it then crystallizes in brilliant short needles. It is composed of $C_{13}H_8O_{14}$, and is an acid ether analogous to phosphovinic ether, its rational formula being,



Ethylomeconic acid, when pure, crystallizes from boiling water, in which it is very soluble, in brilliant small crystals, which, when magnified, are seen to be square prismatic needles. It likewise dissolves readily in ether and common alcohol when warmed, less readily in absolute alcohol. It separates from concentrated solutions in these three liquids in groups of stellate crystals, and when left to spontaneous evaporation, in long needles. It is anhydrous; its crystals lose no weight either *in vacuo* or at 100°C . It fuses at about 158° — 159°C . to a transparent yellowish liquid, a sublimate of very brilliant rhombic crystals being formed at the same time. The aqueous solution has a strongly acid reaction, imparts a deep-red colour to persalts of iron, and decomposes carbonates with effervescence. It is bibasic, forming two series of salts; the acid salts are readily crystallizable. Its salts are very stable, the acid being recoverable from them by decomposition with stronger acids.

Acid Ethylomeconate of Baryta, $\text{BaO} \cdot \text{HO} \cdot C_4H_5O \cdot C_{14}HO_{11}$, is formed on adding carbonate of baryta in successive small portions to water covering solid ethylomeconic acid. Lively effervescence ensues, and the acid quickly disappears, a small quantity of an insoluble yellow salt being formed at the same time. If the liquid be filtered as soon as the effervescence ceases, and the vessel be placed *in vacuo*, a considerable quantity of carbonate of lime previously held in solution by the carbonic acid is deposited. By a second filtration, a clear, yellowish liquid is obtained, which, when evaporated *in vacuo*, or at a gentle heat, yields well-defined, brilliant, rhombic crystals of a yellow colour. The crystals contain water, which they lose on drying.

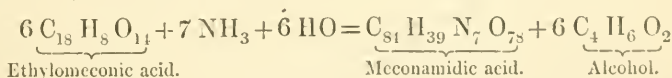
Acid Ethylomeconate of Silver, $\text{AgO} \cdot \text{HO} \cdot C_4H_5O \cdot C_{14}HO_{11}$.—Obtained by adding an aqueous solution of the baryta-salt to nitrate of silver, dissolving the washed precipitate in boiling water, and crystallizing. Forms groups of fine, small, stellate crystals, brilliant

and white. It is remarkably stable, remaining perfectly unchanged when exposed for a long time to the diffused daylight of summer. The crystals contain 2 atoms water, which they give off at 100°C .

An aqueous solution of acid ethylomeconate of baryta forms with acetate of lead a yellowish-white, with sulphate of copper a pale green, and with perchloride of iron a red-brown precipitate; the last is readily soluble in an excess of the iron-salt, forming with it a dark red liquid.

Neutral Salts of Ethylomeconic Acid.—These salts have not yet been obtained quite pure. By saturating ethylomeconic acid with carbonate of baryta at 100°C . and filtering, a salt was obtained in small, short, yellow needles, which, when dried at 100° , yielded 41.89 per cent baryta. The formula, $\text{BaO} \cdot \text{C}_4\text{H}_5\text{O} \cdot \text{C}_{14}\text{H}_{11}\text{O}_{11}$, requires 42.19. The salts obtained by treating the acid with excess of carbonate of baryta were found to contain from 42 to 44.5 per cent baryta; whence it would appear that the acid forms basic in addition to neutral and acid salts. Similar results were obtained with the other alkaline earths. The acid, when heated with excess of carbonate of silver, remains almost wholly undissolved in the form of some basic compound; heated with excess of potash or soda, it yields *meconates* of these bases. An excess of caustic ammonia decomposes it very readily.

Meconamidic Acid.—When ethylomeconic acid is dissolved in warm water or alcohol, and an excess of strong aqueous or alcoholic ammonia is added, the liquid assumes a deep-yellow colour, and becomes very soon filled with a yellow, semi-gelatinous substance, which, after being washed with dilute spirit, dries up in the air to an amorphous mass, reducible with some difficulty to a very fine yellow powder. It appears to be the ammonia-salt of a peculiar acid; for, on treating its solution in hot water with hydrochloric acid, a white precipitate is formed, which, on being recrystallized from boiling water, is found to have the composition, $\text{C}_{84}\text{H}_{39}\text{N}_7\text{O}_{78}$. It appears to be formed by the action of 7 atoms ammonia on 6 atoms of the acid ether, thus:



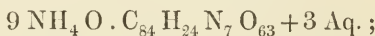
If we suppose that the acid contains 6 atoms water of crystallization which are not given off at 100°C ., its formula will be $\text{C}_{84}\text{H}_{33}\text{N}_7\text{O}_{72}$; which contains the elements of 6 atoms normal amidomeconic acid + 1 atom ammonia.



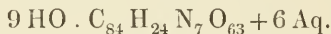
The numbers obtained by analysis do not agree very well with this view of its constitution; but that it is really an amidogen-compound resulting from meconic acid, may be inferred from the fact that when

it is heated with a solution of potash, ammonia is evolved in considerable quantity, and the liquid gives with hydrochloric acid a crystalline precipitate consisting of bimeconate of potash, which, upon subsequent treatment, in the same manner, is converted into meconic acid.

The appropriation of the atom of ammonia among the 6 atoms of amidomeconic acid (if indeed this be the constitution of the compound), appears to have much diminished the basicity of the complex atom, or else the yellow salt is not a neutral one. The amidomeconic acid being bibasic, 6 of its atoms should, in forming a neutral salt, take up 12 atoms ammonia; but it appears to contain only 9 atoms, its formula as deduced from analysis being



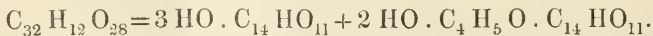
and the acid itself considered with regard to its amount of basic water as indicated in the salt, is represented thus:



The yellow salt when examined by the microscope does not present any appearance of crystalline structure, but appears to consist of round translucent granules, which, when deposited slowly from dilute solutions, look like small yellow vesicles or air-bubbles. It dissolves readily in hot water, exhaling a decided smell of ammonia; it is very sparingly soluble in hot alcohol, insoluble in cold alcohol. It gradually gives off ammonia when heated in the dry state to 100°C. ; at a higher temperature it blackens and fuses.

Attempts were made to prepare the other salts of the acid by precipitating metallic solutions with the ammonia-salt; but no definite products were obtained.

Coupled Ether of Meconic Acid.—Mecono-ethylomeconic Acid.—This is the substance already described as occurring in the process of making the ethers of meconic acid when rectified spirit is employed; it is deposited generally after the first product of ethylomeconic acid is filtered off. On redissolving it in hot water two or three times, and cooling the liquid, a white amorphous powder is obtained, the analysis of which agrees pretty nearly with the formula $\text{C}_{32} \text{H}_{12} \text{O}_{25}$, which contains the elements of 1 atom meconic and 1 atom ethylomeconic acid:



That the substance is more than an accidental mixture appears from its behaviour with ammonia. On adding alcohol to a concentrated aqueous ammoniacal solution of the substance, a deposit appears consisting of small radiated silky tufts; and when such an aqueous solution is evaporated to dryness at 100°C. , a crystalline residue remains, which is very sparingly soluble in boiling water; the more

soluble portion gives with hydrochloric acid a crystalline precipitate in the form of needles. Want of material prevented the further examination of these products.

Biethylomeconic Acid, $\text{HO} \cdot 2 \text{C}_4 \text{H}_5 \text{O} \cdot \text{C}_{14} \text{HO}_{11}$.—This substance is found in considerable quantity in the acid mother-liquors from which the bodies before described have been deposited, especially when absolute alcohol has been used, its proportionate amount appearing to depend on that of the hydrochloric acid gas passed through the solution. It remains, on evaporating the liquid till acid ceases to be evolved at 100°C . in the form of a thick oil or viscid mass, which becomes a crystalline solid on cooling. It may be purified by recrystallization.

The same compound may be obtained by distilling meconic acid with absolute alcohol and strong sulphuric acid. Alcohol and ether distil over, and a syrupy mass remains, which, when poured into a comparatively large quantity of cold water, yields after a while a crystalline precipitate of a rose-pink colour. On recrystallization from water, it formed colourless flattened prisms, which, when dried at 100° , were found to be identical in composition with the above. Rectified spirit cannot be substituted for absolute alcohol in this process.

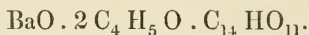
Biethylomeconic acid, in its pure state, as crystallized from water, occurs in the form of long, flattened, colourless prisms; under boiling water it fuses before dissolving. It is very soluble in alcohol. In the dry state it fuses at about 110°C . to a yellowish transparent liquid. Its aqueous solution readily coagulates white of egg, has an acid reaction, and decomposes carbonates with effervescence. It imparts a red colour to ferric salts. It is monobasic.

Biethylomeconate of Ammonia.—When ammoniacal gas is passed through a solution of the ether in nearly absolute alcohol, the whole becomes a yellow nearly solid mass; and this when freed by pressure from the ammoniacal alcohol, and dissolved in hot spirit, crystallizes in tufts of radiated, yellow, silky needles. This salt contains no water, its composition being expressed by the formula,



Biethylomeconate of ammonia dissolves readily in cold water, forming a yellow solution from which acids throw down the unchanged ether. The solution gives the following reactions: With nitrate of silver a yellow gelatinous precipitate, insoluble in boiling water, and apparently unaltered by elevation of temperature; with sulphate of copper, a green gelatinous precipitate; with acetate of lead, a heavy yellowish-white; with sulphate of magnesia, a crystalline precipitate; with the chlorides of barium, strontium, and calcium, it produces pale yellow, semi-gelatinous precipitates, inso-

luble in boiling water, but readily soluble in excess of the earthy salts. The baryta-salt dried at 100° C. has the composition



Biethylomeconic acid, when *heated* with ammonia, appears to undergo a change, the result of which is probably an acid amide.

On some Salts and Decomposition-Products of Pyromeconic Acid.

By James Brown.*

Pyromeconic acid was discovered by Sertürner, and long regarded as sublimed meconic acid, till Robiquet, in 1832, obtained meconic acid, the substance from which pyromeconic acid is formed, and showed that the acid obtained from opium exhibits characters different from those of the sublimed acid. He prepared the lead-salt of pyromeconic acid, and showed that its formula is $\text{PbO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5$. Liebig pointed out that pyromeconic acid has the same composition as pyromucic acid, and regarded it as probable that the two acids were identical. This supposition, however, has been completely refuted by Stenhouse.

The pyromeconic acid used in the following investigation was prepared by distilling impure meconic acid (prepared by twice treating crude meconate of lime with hydrochloric acid) at a temperature between 260° and 315° C. It was purified by once pressing it between bibulous paper, and then subliming at rather a low temperature, in a cylindrical vessel fitted with a number of transverse diaphragms of filtering-paper. By this treatment, the acid was obtained colourless and pure enough for the preparation of all its salts and products of decomposition.

The acid thus obtained assumes the form of large, beautiful, transparent tables, which dissolve readily in water and alcohol, both at high and at low temperatures, from which solutions it again crystallizes in tolerably large four-sided prisms. It is slightly acid to litmus-paper, and retains this acid reaction even after three crystallizations from boiling water. It volatilizes completely at 100° C., a property which may be used to test its purity from parameconic acid (with which it is always contaminated at the first sublimation), inasmuch as the latter requires a much higher temperature to volatilize it.

Pyromeconic acid gives a deep red colour with ferric salts, and forms no precipitate with the chlorides of calcium, barium and man-

* Phil. Mag. [4], IV, 16.; Ann. Ch. Pharm. LXXXIV, 32.

ganese, or with sulphate of magnesia, either at high or at low temperatures, even on the addition of ammonia. With corrosive sublimate, it forms after a while a white amorphous precipitate which redissolves on boiling. On treating a hot aqueous solution of pyromeconic acid with strong caustic potash in excess, and leaving it to stand for some hours, it soon yields crystals consisting of the acid in its original state. A similar experiment was made with ammonia, but it led to the same result: in both cases, the liquid became nearly black.

The formula of pyromeconic acid is $\text{HO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5$, or $\text{C}_{10} \text{H}_4 \text{O}_6$.

Pyromeconate of Baryta.—Obtained by mixing a warm ammoniacal solution of pyromeconic acid with acetate of baryta, the salt being then deposited, after a short time, in small, colourless, silky needles. In dilute solutions they do not form immediately, but their formation goes on very quickly when once begun.

This baryta-salt is the most soluble of all the earthy pyromeconates: water at 15.5°C . dissolves 2.50 per cent of it. It is but slightly soluble in alcohol. Like all the pyromeconates, it has a strong alkaline reaction, and gives with sesquichloride of iron a faint red colouring, which, however, is stronger when crystals of the salt are used instead of the solution. On evaporation *in vacuo*, the salt is deposited in short prisms of a yellowish colour. It loses nothing in weight by exposure to a temperature of 100° , but when more strongly heated, it burns with slight incandescence, without previously melting. The salt, when thoroughly washed with alcohol and dried at 100°C ., was found to contain $\text{BaO} \cdot \text{C}_{10} \text{H}_4 \text{O}_6$, or $\text{BaO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5 + \text{HO}$.

Pyromeconate of Strontia, $\text{SrO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5 + \text{HO}$.—On mixing an alcoholic solution of nitrate of strontia with an alcoholic solution of pyromeconic acid which has been made ammoniacal, a precipitate is immediately formed, consisting of small, silky needles, which, by recrystallization from water may be obtained in stellate groups having a yellowish colour. The salt obtained by precipitation is colourless, slightly soluble in water and alcohol at ordinary temperatures, more soluble at higher temperatures, and has a strong alkaline reaction. Water at 20°C . dissolves 1.3 per cent of it. It does not lose weight at 100° ; at higher temperatures it does not melt, but burns with a slight explosion.

Pyromeconate of Lime, $\text{CaO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5 + \text{HO}$.—Obtained in the form of small, colourless, silky needles by adding an excess of a solution of acetate of lime to a warm ammoniacal solution of pyromeconic acid. It is slightly soluble in warm alcohol, somewhat more soluble in water, from which it crystallizes as the solution gradually cools, in crystals of considerable magnitude. Water at 15.5°C . dissolves 0.31 per cent of it.

Pyromeconate of Magnesia, $\text{MgO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5$.—A warm aqueous solution of pyromeconic acid forms with acetate of magnesia a white

amorphous precipitate insoluble in water and alcohol. The reactions of this salt are exactly like those of the other pyromeconates. It does not lose weight at 100° . It appears to be the only earthy pyromeconate which contains no water.

Pyromeconate of Lead, $\text{PbO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5$.—Robiquet obtained this salt by adding hydrated oxide of lead to a hot solution of pyromeconic acid. It may also be formed by adding a warm concentrated ammoniacal solution of pyromeconic acid to acetate of lead, whereupon there is immediately deposited a dense crystalline powder, which rapidly increases if the liquid be briskly stirred. The crystals are but sparingly soluble in hot water, and still less soluble in alcohol whether hot or cold. The precipitated salt is colourless, but when exposed to daylight quickly turns yellow. It does not lose weight at 100° , even in the course of three or four hours.

Pyromeconate of Copper, $\text{CuO} \cdot \text{C}_{10} \text{H}_3 \text{O}_5$.—Stenhouse obtained this salt by boiling the acid with hydrated oxide of copper, and leaving the filtered solution to cool. It may also be formed by mixing ammonis-sulphate of copper with a warm aqueous solution of pyromeconic acid; a precipitate is then formed, consisting of green, shining, crystalline needles, which are very brittle and easy to pulverize. The crystals require a tolerably large quantity of hot water to dissolve them; in cold water and in alcohol they are but very slightly soluble.

Pyromeconate of Ferric Oxide, $\text{Fe}_2 \text{O}_3 \cdot 3 \cdot \text{C}_{10} \text{H}_3 \text{O}_5$.—This salt has been fully described by Stenhouse, who obtained it by boiling pyromeconic acid with hydrated ferric oxide, or with ferric sulphate. It may likewise be formed by adding sesquichloride of iron to a hot concentrated aqueous solution of the acid; cinnabar-coloured crystals then gradually appear, and attach themselves to the sides and bottom of the vessel.

DECOMPOSITION-PRODUCTS OF PYROMECONIC ACID.

When a few crystals of pyromeconic acid are moistened with strong nitric acid, they immediately assume a white gelatinous appearance, and bubbles of nitrous acid are soon given off. On applying a moderate heat, the action becomes extremely violent, and remains so, even if the application of heat be discontinued; oxalic acid and hydrocyanic acid are simultaneously produced.—Sulphuric acid does not act on pyromeconic acid in the cold, but dissolves it at a gentle heat, forming a colourless liquid, from which the pyromeconic acid is again deposited on cooling.—When chlorine is passed into a solution of pyromeconic acid, no substitution-product is formed, the action being apparently too violent for that result; in fact, the acid is completely decomposed, and the liquid is afterwards found to contain oxalic acid, though not in large quantity.—The author did not succeed in form-

ing an ether by passing dry hydrochloric acid gas through a solution of the acid in absolute alcohol, the crystals which separated out from the liquid proving to be nothing but the unaltered acid.

Action of Bromine on Pyromeconic Acid.—When bromine water is added to a strong aqueous solution of pyromeconic acid, the latter being in excess, the bromine is quickly taken up, and there remains a colourless liquid, which, after standing for an hour or less, deposits beautiful, small, colourless crystals of *Bromopyromeconic Acid*,

$C_{10} \left\{ \begin{smallmatrix} H_3 \\ Br \end{smallmatrix} \right\} O_6$. This acid is slightly soluble in cold water, somewhat

more soluble in hot water, and reddens litmus slightly. It dissolves readily in boiling alcohol, and crystallizes from this solution in beautiful tables, which, however, if the cooling be carefully conducted, are replaced by short prisms. With ferric salts, the acid gives a deep purple-red colour, totally distinct from the red produced by the original acid. Nitric acid decomposes it with effervescence, but sulphuric acid dissolves it without visible decomposition. When subjected to dry distillation, it fuses and afterwards blackens, giving off hydrobromic acid in large quantity. If the heat be allowed to act upon it for a longer time, a white crystalline substance begins to collect in the cold part of the tube; but the quantity of this substance obtained was too small for examination. The acid gives no precipitate with nitrate of silver, and does not reduce the oxide to metallic silver on boiling; neither does it produce any precipitate in solutions of chloride of barium, chloride of calcium, or sulphate of magnesia, even in presence of ammonia. With ammonio-sulphate of copper it exhibits no reaction in the cold, but on the application of heat a bluish precipitate is formed.

Bromopyromeconic acid is monobasic, like pyromeconic acid.

Lead-salt, $PbO \cdot C_{10} H_3 Br O_5 + HO$.—A warm alcoholic solution of the acid forms, with an alkaline solution of acetate of lead, a white precipitate, consisting of small, dense, crystalline needles, which quickly settle down to the bottom of the vessel. This salt may also be obtained by mixing the aqueous solutions of the acid and of acetate of lead, and adding ammonia; but when thus prepared, it is very dark-coloured. It does not lose weight at 100° .

The author has likewise obtained a substitution product of pyromeconic acid with iodine.

Researches on Chemical Affinity.

By R. Bunsen.*

FIRST MEMOIR.

The force which is regarded as the cause of chemical affinity may, as is well known, be increased and diminished by various influences. Its magnitude varies under the influence of light, heat, and electricity; it changes with the proportion of the acting masses, and is essentially modified by the state of aggregation of matter, as well as by the contact of the acting body with bodies substantially different. It may, therefore, be regarded as a function of all these influences. If the mathematical form of this function could be determined, it would afford a measure of the absolute magnitude of the force itself.

Claude Berthollet, the celebrated author of the "Statique Chimique," was the first to regard the cause of chemical phenomena from this point of view. His sagacious contemplations led him to assume that particular law of the action of masses, which was named after him, and is still at the present day regarded as valid, and by which he thought he could express the relation of the force of chemical affinity to the mass of the combining bodies. According to this law, a body, to which two different substances capable of uniting chemically with it, are presented in different proportions, divides itself between these substances, in the ratio of the products of their relative masses into the absolute strengths of their chemical affinities for it. Thus, if the masses of the two bodies which are present in excess be denoted by A and B , the respective coefficients which denote their absolute affinities for the body C by α and β , and the quantities of A and B which actually combine with C by a and b ; then will these quantities be to another as αA , βB , i. e.:

$$a : b = \alpha A : \beta B.$$

Hence the rates of the absolute affinity of A to C , and B to C , is given by the equation:

$$\frac{\alpha}{\beta} = \frac{aB}{bA}$$

It appeared to me a matter of great interest to subject this law, which as yet is destitute of any experimental support, to an exact investigation. The result of this examination has been to establish not Berthollet's, but a totally different law, which promises to exert a not unimportant influence on our views of the mode of action

* Ann. Ch. Pharm. LXXXV, 137.

of chemical affinity. The substance of this new law may be comprised in the following theorems.

1. When two or more bodies, B, B' , are presented in excess to the body A , under circumstances favourable to their combination with it, the body A always selects of the bodies $B, B' \dots$ quantities which stand to one another in a simple stoichiometrical relation; so that for 1, 2, 3 $\dots$ atoms of the one compound, there are always formed 1, 2, 3, 4 $\dots$ atoms of the other.

2. If in this manner there is formed an atom of the compound $A' + B'$ in conjunction with an atom of $A + B$, the mass of the body B may be increased relatively to that of B' up to a certain limit, without producing any change in that atomic proportion.

3. When a body A exerts a reducing action on a compound $B + C$, present in excess, so that A and B combine together, and C is set free; then if C can, in its turn, exert a reducing action on the newly formed compound, the final result of the reaction is such, that the reduced part of $B + C$ is to the unreduced portion in a simple atomic proportion.

4. In these reductions, also, the mass of the one constituent may, without altering the existing atomic relation, be increased up to a certain limit, above which that relation undergoes changes by definite steps, but always in the proportion of simple rational numbers.

It is not surprising that these remarkable relations have hitherto passed unobserved, seeing that they only arise when the phenomena of combination, which are regulated by them, take place quite simultaneously. For even if the body A were originally to select for combination from the bodies B and C , quantities bearing to one another a simple atomic relation, but the combination of A and B were to take place in shorter time than that of A and C , it would follow of necessity that, during the whole term of the process, the ratio of B to C , and consequently also the mutual atomic relation of the associated compounds would change, so that the observed proportion would be no longer definite, but mixed. The same result must follow, if the bodies which are combining side by side be not homogeneously mixed in the beginning. The law will, therefore, be most easily recognisable when these relations do not exert a disturbing action, as, for example, in combustible gases, which before combustion exist in a condition of static equilibrium. I shall, therefore, in the following investigations, chiefly avail myself of such mixtures.

When carbonic oxide and hydrogen are exploded with a quantity of oxygen not sufficient to burn them completely, the oxygen divides itself between the two gases, according to the law above mentioned, in such a manner that the quantities of carbonic acid and water produced, stand to one another in a simple atomic proportion.

The combustions were made in a eudiometer, which allowed the

pressure to be varied at pleasure. (For the description of the apparatus, see the original Memoir). The hydrogen used in the experiments was obtained by electrolysis, and the carbonic oxide by the action of sulphuric acid upon formiate of magnesia; the latter, after being washed with potash-ley, was found to be quite pure.

I. A mixture of detonating gas (2 vol. H + 1 vol. O, obtained by electrolysis), and carbonic oxide, containing, in 100 parts :

Carbonic oxide	72·57
Hydrogen	18·29
Oxygen	9·14
	100·00

was divided into two portions. The first portion, burnt in the dark at $0^{\text{m}}\cdot 7338$ and $22\ 3^{\circ}\text{C.}$, gave for the proportions of CO and H consumed :

	Found.		Calculated.
Carbonic oxide . . .	12·28	2 vols.	12·19
Hydrogen	6·00	1 vol.	6·09
	18·28		18·28

II. The second portion, burnt in the dark at $0^{\text{m}}\cdot 7324$ and $22\cdot 5^{\circ}\text{C.}$, gave :

	Found.		Calculated.
Carbonic oxide . . .	12·09	2 vols.	12·19
Hydrogen	6·19	1 vol.	6·09
	18·28		18·28

III. A similar mixture, containing, in 100 parts :

Carbonic oxide	59·93
Hydrogen	26·71
Oxygen	13·36
	100·00

when burned in daylight, at $0^{\text{m}}\cdot 3952$ and $22\cdot 5^{\circ}\text{C.}$, gave, for the quantities consumed, in 100 parts :

Carbonic oxide . . .	13·06	1 vol.	13·36
Hydrogen	13·66	1 „	13·36

In Exp. I. and II., the ratio of the oxygen to the combustible gases was 10 : 99·4, and that of the hydrogen to the carbonic acid, 10 : 39·7. The mixture gave, in two combustions, the proportions of 1 vol. hydrogen burned to 2 vols. carbonic oxide.

In Exp. III., a gaseous mixture, containing only 64·9 vols. combustible gases to 10 vols. oxygen, and only 22·2 vols. carbonic oxide to 10 vols. hydrogen, gave equal volumes of the gases consumed.

In the following experiments, a mixture was used containing :

Carbonic oxide	36·70
Hydrogen	42·17
Oxygen	21·13
	100·00

IV. The gas was burned in three portions ; the first, burned in sunshine at 0^m·7264 and 22·5° C., gave for the quantities consumed :

	Found.		Calculated.
Carbonic oxide	11·01	1 vol.	10·56
Hydrogen	31·25	3 vols.	31·70
	42·26		42·26

V. The second portion, burned in the dark at 0^m·7230 and 22·6° C., gave :

	Found.		Calculated.
Carbonic oxide	10·65	1 vol.	10·57
Hydrogen	31·61	3 vols.	31·69
	42·26		42·26

VI. The third portion, burnt in daylight at 0^m·3169 and 22° C., gave :

Carbonic oxide	10·71	1 vol.	10·59
Hydrogen	31·55	3 vols.	31·67
	42·26		42·26

VII. The next experiment was made with a mixture containing in 100 vols. :

Carbonic oxide	40·12
Hydrogen	47·15
Oxygen	12·73
	100·00

Burned in daylight at 23° C. and 0^m·7200, it gave for the quantities consumed :

	Found.		Calculated.
Carbonic oxide	4·97	1 vol.	5·09
Hydrogen	20·49	4 vols.	20·37
	25·46		25·46

VIII. Another mixture, of unknown composition, gave :

	Found.		Calculated.
Carbonic oxide . . .	4.95	1 vol.	5.07
Hydrogen	10.27	2 vols.	10.15

In the mixture with which the Experiments IV., V. and VI. were made, the oxygen was to the combustible gases as 10 : 37.3, and the hydrogen to the carbonic oxide as 10 : 8.7. The three experiments show that the volumes of H and CO consumed were as 3 : 1, whether the pressure to which the gases were subjected was 0^m.7264, or 0^m.3169, and whether the combustion took place in the dark, or in daylight. In Exp. VII., the oxygen was to the combustible gases as 10 : 68.5, and the hydrogen to the carbonic oxide as 10 : 8.5. From this mixture, the oxygen took 4 vols. H to 1 vol. CO. Lastly, in Exp. VIII., the combustion produced 2 vols. vapour of water to 1 vol. carbonic acid.

The proportions of hydrogen and carbonic oxide consumed on these several gaseous mixtures, correspond to five hydrates of carbonic acid of the following forms :



Hence it might be imagined, that the cause of the combustion taking place in these atomic proportions is to be found in the actual formation of these hydrates. Closer consideration, however, will show that such a supposition is wholly untenable. It may, indeed, be easily shown that carbonic acid does not form any definite compound with water—at least, at ordinary temperatures. The author has shown (in a research not yet published, on the absorption of gases by liquids), that the coefficient of absorption of carbonic acid by water, which is 0.8545 at 19.6° C., and 1.4698 at 4.4° C., varies exactly in proportion to the density of the gas, at least, within the limits observed, and consequently exhibits a relation which is totally inconsistent with the formation of a hydrate of carbonic acid. Hence it is impossible to believe that carbonic acid can form as many as four or five definite compounds with water. But even if this supposition were admissible, it would still be contrary to all chemical experience that the compound 2 HO. CO₂ should be formed at the lowest, the compound 3 HO. CO₂ at a higher, and the hydrate 4 HO. CO₂ at the highest temperature. We find, on the contrary, in all cases hitherto observed, that the lower hydrates of acids bear, without decomposition, much higher temperatures than those which contain a larger quantity of water. We cannot, therefore, suppose that the compound 4 HO. CO₂, formed at the highest temperature, is incapable of existing at a lower temperature, and that instead of it only the compounds 3 HO. CO₂, 2 HO. CO₂, or HO. CO₂, are formed. But there is yet another circumstance which speaks most decidedly against this hypothesis. All the known compounds of acids with several

atoms of water are incapable of existing at very high temperatures, whereas, these hydrates of carbonic acid, if they exist, must be formed only at the highest temperatures, and must, on cooling, be again resolved into carbonic acid and water. And even if all these contradictions could be reconciled, by the assumption that at the high temperatures at which the combustion of the gases takes place, the combining tendencies may be the reverse of those which are observed at lower degrees of heat, we should still only encumber ourselves with new difficulties; for there are other phenomena relating to the same point, which even this assumption is unable to explain.

When oxygen is passed over red-hot charcoal, carbonic acid is formed; but this gas, by the further action of the charcoal, is completely converted into carbonic oxide. If the oxygen gas be replaced by vapour of water, the charcoal is likewise oxidized, and hydrogen separated. The action does not, however, proceed to the complete formation of carbonic acid, but stops when for every 4 vols. hydrogen separated, there have been formed exactly 1 vol. carbonic acid, and 2 vols. carbonic oxide. A gaseous mixture, obtained by this process, gave by analysis the following results:

	Found.		Calculated.
Hydrogen	56.52	4 vols.	57.14
Carbonic oxide	28.71	2 „	28.57
Carbonic acid	14.77	1 vol.	14.29
	100.00		100.00

The same composition is found in a similar gaseous mixture analysed more than fifty years ago by Clement and Desormes:

Hydrogen	56.22
Carbonic oxide	28.96
Carbonic acid	14.63
Marsh-gas	0.19
	100.00

If, now, we suppose that the simple atomic relation of the simultaneously formed products of decomposition results from a combination formed according to the same proportion, we are met by an irreconcilable contradiction. For since the products of oxidation thus formed contain 4 atoms oxygen to 3 atoms carbon, we should, on the hypothesis just mentioned, be obliged to admit that a body having the composition of mesoxalic acid is formed at a red heat, and resolved on cooling into carbonic oxide and carbonic acid,—unless indeed we were to take refuge in the still more absurd supposition that an organic compound, $C_3H_4O_4$, corresponding in composition to the decomposition-products obtained, has actually existed at the red heat, but has been resolved on cooling into hydrogen, carbonic oxide and carbonic acid.

Especially remarkable is the behaviour of cyanogen when imperfectly burned. Nitrogen is then set free, and carbonic acid and carbonic oxide produced in quantities which bear to one another, as the law requires, a simple atomic relation. The experiment is difficult, inasmuch as the combustion must be made at a temperature low enough to prevent any partial oxidation of the nitrogen. To this end it is necessary to ascertain by preliminary experiments the limits of inflammability of cyanogen, and then, having made a mixture in proportions near that limit, to compress it so far that the limit of inflammability may be just passed, and the combustion in the eudiometer may take place without sublimation of mercury. In this manner a mixture of cyanogen, free oxygen and atmospheric air containing in 100 parts :

Cyanogen	18.05
Oxygen	28.87
Nitrogen	53.08
	100.00

yielded by combustion the following products :

Nitrogen	17.42	3 vols.	17.42
Carbonic oxide	11.93	2 vols.	11.61
Carbonic acid	22.90	4 vols.	23.22
	52.25		52.25

Hence it appears that the oxygen unites with the carbon of the cyanogen, not to form carbonic acid or carbonic oxide alone, but both together, and moreover in a simple atomic proportion, as if the compound $\text{CO} \cdot 2 \text{CO}_2$ or C_3O_5 had been formed. As it is not possible by altering the proportions of this mixture to attain the limit at which this particular proportion passes into another, without incurring the disturbing effect of a simultaneous oxidation of the nitrogen, I have been obliged to give up the further prosecution of the experiments with mixtures containing cyanogen.

A wider range is afforded by experiments with a mixture of carbonic acid with hydrogen and oxygen, in the combustion of which the carbonic acid is exposed at the same time to the reducing action of the hydrogen and the oxidizing action of the oxygen. These experiments demonstrate the remarkable fact that the phenomena of reduction likewise take place in such a manner that the reduced and unreduced portions of the compound bear to each other a simple atomic relation.

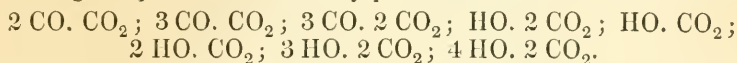
The contraction which a mixture of carbonic acid and hydrogen suffers by combustion with detonating gas is equal to the volume of the carbonic oxide formed. Moreover, as the latter is equal to that of the carbonic acid reduced, we have only to deduct the observed contraction from the volume of carbonic acid originally present in the

mixture, and the difference will give the portion of carbonic acid which has escaped reduction.

A mixture of carbonic acid, hydrogen and detonating gas containing 8.52 per cent carbonic acid, 70.33 hydrogen and 21.15 oxygen, yielded in this manner 3 vols. carbonic oxide to 2 vols. carbonic acid, just as if 5 atoms CO_2 had been reduced to the compound C_5O_7 , or as if the compound $3\text{CO} \cdot 2\text{CO}_2$ had been formed.

The gas remaining after the combustion in the last experiment was again mixed with detonating gas in such proportion as to form a mixture containing 4.41 per cent carbonic oxide, 2.96 carbonic acid, 68.37 hydrogen and 24.26 oxygen. The combustion produced an expansion, showing that a portion of carbonic oxide had been burnt and converted into carbonic acid; and the quantity of CO thus oxidized was to that which remained unaltered as 1 vol. to 3 vols. corresponding to the compound C_4O_5 or $3\text{CO} \cdot \text{CO}_2$.

On collecting the results of all these experiments, it appears that the reducing and oxidizing actions of oxygen are exerted as if the following compounds were thereby produced:



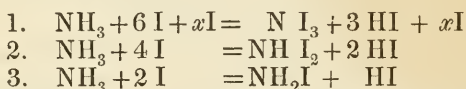
If the formulæ thus determined, nearly all of which correspond to unknown compounds, could be regarded as the expressions of really existing substances, a mode would be found of determining beforehand, by experiment, the atomic relations of compounds yet unknown. But whatever signification may be attached to these remarkable formulæ, and whatever other relations may lie hid in them, they must even now be regarded as the expression of a peculiar mode of action of chemical affinity; and the numbers which enter into them must be distinguished, as *coefficients of affinity*, from the atomic numbers which are *coefficients of combination*.

Although the results of the preceding investigation must modify considerably our ideas of the mode of action of chemical affinity, I refrain for the present from any interpretation of the law above enumerated. It appears to me to be essential to ascertain whether the same law holds good for liquids, and to assign the conditions which determine the alteration of the coefficients of affinity. The limits at which these coefficients suddenly pass from one rational proportion to another, and at which therefore the force of affinity is, as it were, in a state of instable equilibrium, promise to afford the most important revelations respecting the influence of other forces, which are here certainly to be detected in their minutest workings, namely, of light and heat, and likewise of mass and contact. These relations will form the subject of a future Memoir.

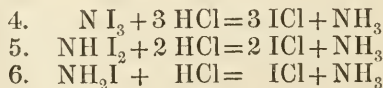
On the Constitution of Iodide of Nitrogen.

By R. Bunsen.*

That the elements of water are not concerned in the formation of iodide of nitrogen, follows from the simple fact that a concentrated solution of iodine in absolute alcohol, on being saturated with anhydrous ammonia, yields iodide of nitrogen without any decomposition of the solvent. Hence we may conclude that iodide of nitrogen contains no oxygen, but only nitrogen, iodine and hydrogen. Moreover, since in the formation of this compound from iodine and ammonia, there is but one secondary product obtained, viz. hydriodic acid, it follows that the so-called iodide of nitrogen must be a substitution-product of ammonia, in which the hydrogen is wholly or partially replaced by ammonia, viz. :



Either of the compounds, 1, 2 or 3, might however contain ammonia or hydriodic acid in addition. But it is easily shown that hydriodic acid cannot enter into the composition of iodide of nitrogen; for this substance dissolves in hydrochloric acid without evolution of gas, forming a liquid which contains ammonia and *protochloride of iodine*, but no hydriodic acid. This reaction shows indeed that iodide of nitrogen is a compound of the form NI_3 , NHI_2 or NH_2I , either alone or combined with the elements of ammonia. Which of these two alternatives is the correct one may be easily decided, if we can find the atomic proportion which the products of the decomposition of iodide of nitrogen by hydrochloric acid bear to each other. For if *ammonia* and *protochloride of iodine* are the only products thus formed, the decomposition must take place in one of the following ways :



Hence it appears that the so-called iodide of nitrogen must be, so to speak, a nitrile, an imide, or an amide of iodine, according as 3, 2 or 1 atom of protochloride of iodine is separated for each atom of ammonia. Similarly we may infer that the separation of 2 atoms of ammonia to 3 atoms of protochloride of iodine would correspond to

* Ann. Ch. Pharm. LXXXIV, 1.

the compound $\text{NH}_3 + \text{NI}_3$, and the separation of 2 atoms of ammonia to 1 atom of protochloride of iodine to the compound $\text{NH}_3 + \text{NH}_2\text{I}$. It follows that the composition of iodide of nitrogen may be determined by the products of its decomposition by hydrochloric acid, viz. :

- I. By the quantity of ammonia formed.
- II. By the composition and quantity of the chloride of iodine.

The ammonia is determined as usual by precipitation with chloride of platinum.—To determine the chloride of iodine the following method was used :

Two equal volumes of the hydrochloric solution of iodide of nitrogen are taken. In the one, the iodine is precipitated by chloride of palladium, after the chloride of iodine has been converted by sulphurous acid into hydrochloric and hydriodic acid. Let the quantity of iodine thus found be i . A known volume of an aqueous solution of sulphurous acid is then taken, in which the quantity of iodine i , required to decompose the sulphurous acid has been determined by a preliminary iodometric experiment. To this solution the second portion of the hydrochloric acid solution of the iodide of nitrogen is added, and the quantity of iodine i'' , then required to decompose the sulphurous acid then determined by similar means. The quantity of chlorine c contained in the chloride of iodine is then given by the equation :

$$\frac{\text{Cl}}{\text{I}}(i, - i'' - i) = c.$$

Lastly, another equal volume of the hydrochloric acid solution is evaporated over the water-bath till all the chloride of iodine is driven off, and the ammonia is determined by precipitation with chloride of platinum.

The iodide of nitrogen used for the analysis was prepared by mixing cold saturated solutions of iodine and ammonia in absolute alcohol. A black powder was precipitated, which could be washed with absolute alcohol without suffering the slightest decomposition. The product thus obtained was dissolved while yet moist in dilute hydrochloric acid : it dissolved readily and without evolution of gas. From the resulting solution three equal volumes were measured out. The first gave 0.3290 grm. chloroplatinate of ammonium. The second gave 0.1156 grm. palladium by ignition of the precipitated iodide of palladium. The third was added to a quantity of sulphurous acid which, according to a preliminary experiment, required 241.6 cub. cent. of iodine-solution (containing 0.005 grm. in a cub. cent.) to decompose it, and the quantity of iodine still required for that purpose after the addition of the hydrochloric acid solution, was found to be 131.4 cub. cent.

Hence the quantity of ammonia = 0.02508 ; also $i = 0.27551$;

$i' = 1.2080$; $i'' = 0.6570$; whence we find for the products of the decomposition :

	Experiment.	Atomic proportion.
Ammonia . . .	0.02508	2.04
Iodine	0.27551	3.00
Chlorine	0.07701	3.00

that is to say, 2 atoms ammonia to 3 atoms protochloride of iodine. Consequently iodide of nitrogen can be nothing else than a compound of ammonia in which the *whole* of the hydrogen is replaced by iodine, with an atom of undecomposed ammonia, as expressed by the formula NH_3, NI_3 : this will appear more plainly from the following comparison of the analytical and calculated results :

Protochloride of Iodine.			Iodide of Nitrogen.		
	Atoms.	Calc.	Found.		
Cl	1	21.85	21.85	N	1
I	1	78.15	78.15	I	3
				NH_3	1
CII			100.00	NH_3, NI_3	
			100.00		100.00

Results nearly of equal accordance were obtained from the analysis of an iodide of nitrogen prepared by the use of less concentrated alcoholic solutions of iodine and ammonia.

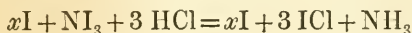
To determine whether iodide of nitrogen precipitated from aqueous solutions has the same composition as that obtained with alcoholic solutions, a dilute solution of iodine in aqua-regia was mixed with ammonia, and the resulting precipitate washed as quickly as possible with such a quantity of cold water, that the remaining mother-liquor could not contain more than 0.01 milligram. ammonia. The analysis of the washed precipitate, conducted as before, led to the formula $\text{NH}_3, 4 \text{NI}_3$:

Protochloride of Iodine.			Iodide of Nitrogen.		
	Atoms.	Calc.	Found.		
Cl	1	21.85	21.94	N	4
I	1	78.15	78.06	I	12
				NH_3	1
CII			100.00	$\text{NH}_3, 4 \text{NI}_3$	
			100.00		100.00

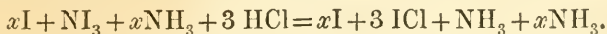
The great facility with which the ammonio-iodide of nitrogen decomposes, with separation of iodine and nitrogen, when continuously washed with water, renders it difficult to decide directly whether the quantity of ammonia actually found in it is really chemically combined or merely mechanically mixed. But an examination of the de-

composition-products obtained from ammonio-iodide of nitrogen by the action of water, leads inevitably to the conclusion that the ammonia is really chemically combined. To establish this conclusion, it is merely necessary to continue the washing till the greater part of the compound is decomposed, with separation of iodine and nitrogen, then dissolve the remaining impure iodized compound in hydrochloric acid, and examine the solution as before.

If by continued washing, the compound NI_3 , free from ammonia, were at last produced, together with free iodine separated as a product of decomposition, the hydrochloric acid solution could not contain more than 1 atom ammonia to 3 atoms chloride of iodine; but if the iodide of nitrogen can only exist in combination with ammonia, then, however long the washing may have been continued, the hydrochloric acid solution will always contain more than 1 atom ammonia to 3 atoms ICl ; thus, in the former case:

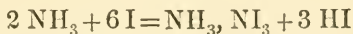


and in the latter:

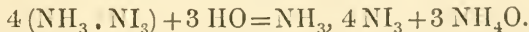


To decide the question, therefore, a portion of the iodide of nitrogen used for the analysis was washed for several hours longer with distilled water, and then left to stand for a while suspended in water. On the addition of hydrochloric acid, a considerably quantity of free iodine remained undissolved. The solution, which, besides ammonia and protochloride of iodine, must likewise have contained free iodine, gave, when analysed as above, results corresponding to 1 atom ammonia and 3 atoms protochloride of iodine, together with free iodine.

We may conclude then that the ammonia forms an essential constituent of the so-called iodide of nitrogen, and that besides the compound $\text{NH}_3 \cdot \text{NI}_3$, there probably exists another, having the composition $\text{NH}_3 \cdot 4 \text{NI}_3$. The manner in which these compounds are formed directly from iodine and ammonia, is easily seen from the following equations:



and:



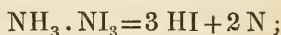
On the other hand, their formation from the chloride of iodine obtained by the action of iodine in aqua-regia would be in direct contradiction to the formula NH_3, NI_3 , if that chloride were really ICl_3 , as sometimes supposed, and not ICl . For the action of ICl_3 on ammonia could not produce NI_3 , but only NI . This discrepancy led the author to suspect that the chloride of iodine obtained in the manner just mentioned, is not really a terchloride but a protochloride,—

a supposition which has been fully confirmed by experiments made in the author's laboratory by Mr. Cohn.

The formation of ammonio-iodide of nitrogen by the action of ammonia on chloride of iodine may therefore be expressed by the following equation :



The view here given of this compound likewise gives an easy account of the changes which take place when it explodes. The first products of the explosive decomposition are nitrogen and hydriodic acid :



but the latter, at the higher temperature which accompanies the decomposition, must be resolved for the greater part into iodine and hydrogen ; while another part of the acid must unite with another part of the compound to form iodide of ammonium, and thereby set free quantities of iodine and nitrogen equivalent to this ammonia.

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

VIII.—*On the Solid Compound obtained by Distilling Stearic Acid with Lime.*

BY THOMAS H. ROWNEY, PH.D., F.C.S.

(ASSISTANT IN THE COLLEGE LABORATORY, GLASGOW.)

Though the solid compounds obtained by the distillation of margaric and stearic acids with lime, have been examined by Bussy, Redtenbacher and Varrentrap, these chemists do not agree in the formulæ given by them to these bodies. Bussy,* to the product obtained from margaric acid, gave the formula $C_{34}H_{33}O$, and to that obtained from stearic acid $C_{68}H_{67}O$. The first of these compounds he named margarone, and the second stearone. Redtenbacher† also describes two compounds: the first, margarone, he considers to be $C_{33}H_{33}O$, and the second to be margarone combined with a hydrocarbon, and to have the formula $C_{45}H_{45}O$, or $C_{33}H_{33}O + C_{12}H_{12}$. Varrentrap‡ likewise gives the formula $C_{33}H_{33}O$ for margarone.

Some time ago, having prepared some of the solid compound by distilling stearic acid with lime, I made an examination of it in order to ascertain the cause of these different statements; but my results differed considerably from those obtained by Bussy, Redtenbacher

* Ann. Ch. Phys. [2] LIII, 1833.

† Ann. Ch. Pharm. XXXV, XXXVI.

‡ Ibid.

and Varrentrap. A reference to their papers on the subject, however, at once made the cause of these different results apparent.

In the following paper I have endeavoured to explain this, first detailing my own experiments, and then comparing the results obtained with those of the previously mentioned chemists.

To obtain the compound, stearic acid as produced in the stearine manufactory was mixed with half its weight of quicklime in an iron pot; this was put into a deep sand-bath and covered with sand, and the distillation carried on rapidly; the distillate whilst hot was quite liquid, but it very soon began to deposit crystals, and when quite cold an abundant crop of crystals was deposited; these were separated from the oily liquid by filtration.

I found the best method of purifying the substance, was to melt it by gently heating it, and then mix some ether with the liquid obtained; by exposure to cold, crystals were deposited; the oily matter retained by the ether was separated from the crystals by filtration. By repeating this process several times, all the oily matter was removed; then, by crystallizing two or three times from boiling ether, the substance was obtained quite pure.

In this state it forms beautiful white crystalline plates, soluble in boiling alcohol, and very soluble in ether; it fuses at 76° C., but after fusion does not solidify until the temperature falls to 72° C.; the fused substance crystallizes on cooling. When cold it may be reduced to powder by rubbing in a mortar, but it becomes highly electrical by friction, so much so, that it is difficult to collect the powder. When heated in a test-tube with strong sulphuric acid, it is decomposed, sulphurous acid is given off, and a black carbonaceous residue left in the tube. Nitric acid does not act upon it even when boiled with it, but it is decomposed when heated with a mixture of strong sulphuric and nitric acids, a volatile oily acid being formed. This decomposition I was not able to follow out, for want of substance. Other oxidizing agents were tried, but with no satisfactory results.

The following numbers were obtained by analysis, the fused substance being employed, and the combustions made with chromate of lead.

I.	·2033	gram. of substance gave :*
	·2535	„ water.
II.	·1770	„ substance gave
	·5355	„ carbonic acid.

* The carbon of the first and the hydrogen of the second combustion were lost.

III.	·1720	gram.	substance gave
	·5165	„	carbonic acid, and
	·2115	„	water.
IV.	·2155	„	substance gave
	·6477	„	carbonic acid, and
	·2660	„	water.

These numbers correspond to the following percentages :

	I.	II.	III.	IV.	Mean.
C . . .	—	82·51	81·89	81·97	82·12
H . . .	13·85	—	13·66	13·72	13·74
O . . .	—	—	—	—	4·14
					100·00

The numbers required for margarone, $C_{33}H_{33}O$, are :

C	82·84
H	13·80
O	3·36
	100·00

which do not agree very well with those obtained by analysis. The experimental numbers, however, agree better with the following formulæ, of which I have given the calculated numbers.

$C_{27}H_{27}O$.		$C_{28}H_{28}O$.	
C	82·23	C	82·35
H	13·70	H	13·72
O	4·07	O	3·93
	100·00		100·00

It will be seen that the difference in the quantities of carbon and hydrogen in these formulæ is very small indeed, and consequently, that it is difficult to decide which formula to adopt, merely from the analysis of the substance itself; but by obtaining a substitution-product I was led to adopt the formula $C_{28}H_{28}O$, or $C_{56}H_{56}O_2$.

Bussy tried the action of chlorine upon his substance, but obtained no satisfactory results. With bromine I have met with better success; but iodine, even when fused with it, has no action upon it.

When bromine is added to the fused substance in a small flask, it acts upon it immediately, hydrobromic acid being given off, and a red oily liquid remains at the bottom of the flask; this solidifies into a crystalline mass when agitated under water; the excess of bromine

was separated from it by washing, first with dilute ammoniacal water, and then with cold alcohol. To obtain the substance pure, it was dissolved in cold ether, and by allowing the ethereal solution to evaporate spontaneously, tufts of feathery crystals were deposited; the mother-liquor was poured off, the crystals were again dissolved in ether, and the solution allowed to evaporate. When this process had been repeated three or four times, very brilliant crystals were obtained. Under the microscope, these were found to consist of square plates collected together into feathery tufts; when viewed by means of polarized light they exhibit a brilliant display of colours; the original substance, on the contrary, shows no colours. The fusing-point of the bromine-compound was found to be from 43° C. to 45° C.

For analysis, the substance was dried *in vacuo* over sulphuric acid, and the combustions were made with chromate of lead.

I.	·3077	grms. of substance gave
	·6740	„ carbonic acid, and
	·2710	„ water.
II.	·2836	„ substance gave
	·6235	„ carbonic acid, and
	·2490	„ water.
II.	·2758	„ substance, burnt with lime, gave
	·1810	„ bromide of silver.

	I.	II.	III.	Mean.
C . .	59·77	59·95	—	59·86
H . .	9·78	9·75	—	9·76
Br . .	—	—	27·93	27·93

On comparing these numbers with the three following formulæ, they will be found to agree best with the formula $C_{28}H_{27}BrO$, which is the one I have adopted, though this probably is not the true atomic weight of the compound.

$C_{27}H_{26}BrO$			$C_{28}H_{27}BrO$			$C_{29}H_{28}BrO$		
C . .	59·03		C . .	59·70		C . .	60·33	
H . .	9·47		H . .	9·58		H . .	9·70	
Br . .	28·56		Br . .	27·85		Br . .	27·18	

From these experiments, it will be seen that I have obtained results differing from those of previous experimenters on this subject: this difference is caused by the atomic weight of carbon having been

altered, it being lower now than at the time of the previous investigations, and the formulæ of stearic and margaric acids have also been altered. Bussy considered the formula of margaric acid to be $C_{35}H_{34}O_4$, but this has since been altered to its present formula, $C_{34}H_{34}O_4$. Redtenbacher, from his analyses, gives the formula $C_{68}H_{68}O_7$, for stearic acid; but his numbers, when recalculated from the present equivalent of carbon, agree with the formula $C_{34}H_{34}O_4$, and the numbers he gives for margaric acid do not agree with the present formula.

Bussy, after several experiments, considered the compound he obtained by distilling margaric acid with lime, to be derived from the anhydrous acid by losing 1 equiv. of carbonic acid; hence the formula given by him, $C_{35}H_{33}O_3 - CO_2 = C_{34}H_{33}O$. Redtenbacher and Varrentrap also consider this to be the reaction, though the formula given by them differs from Bussy's, owing to the difference in the formula of the acid; but a comparison of the properties of the substance, and the numbers obtained by analysis, shows that the compounds examined by them were the same, and also that they agree with that examined by myself, as will be seen by the following table of the corrected numbers of Bussy's, Redtenbacher's, and Varrentrap's, along with those obtained by myself, and the theoretical numbers:

	Bussy.	Redtenbacher.	Varrentrap.	T.H.R.	Theory $C_{34}H_{33}O$.
C . .	82.20	82.39	82.00	82.12	82.35
H . .	13.51	13.86	13.78	13.74	13.72
O . .	4.29	3.75	4.22	4.14	3.93

The fusing-point of the substance was found to be—

Bussy.	Redtenbacher.	Varrentrap.	T.H.R.
77° C.	77° C.	76° C.	76° C.

The numbers of the compound obtained by Redtenbacher, by distilling stearic acid with lime, and to which he gave the formula $C_{45}H_{45}O$, when corrected, agree with the formula $C_{33}H_{33}O$: they also agree with other formulæ, the percentage difference in the carbon and the hydrogen being very small in the different formulæ, as previously stated. As he only made one analysis of the compound, and the fusing-point is near that of the first compound, it is doubtful whether it really is the true margarone. The compound obtained from stearic acid by Bussy must also be considered doubtful, as the numbers he obtained do not agree with any probable formula.

The experiments of Bussy, Redtenbacher, and Varrentrap,

together with my own, show that stearic and margaric acids, when distilled with lime, yield the same products of decomposition. The solid compound is also obtained under the following circumstances: By distilling the acids *per se*; secondly, by distilling the lime, baryta, or potassa-salts of these acids; and, thirdly, by distilling the acids with lime or baryta.

It will be seen that the decomposition proceeds further in this case, than when acids, lower in this series, are treated in a similar manner. This is probably owing to the high temperature required to distil the compound over.

As the name stearone or margarone is not applicable to this compound, I have given it the provisional name of *Stearene*, until something more definite is known of its constitution.

Since this examination has been finished, Messrs. Delffs and Overbeck* have described three compounds, obtained by distilling the lime or baryta-salts of myristic, cocinic, and laurostearic acids, and which they have named myristone, cocinone, and laurostearone; but I do not think the formulæ given by them are quite correct, as the numbers given by them will agree with several formulæ, the hydrogen in all the analyses being far too high for the formulæ of those compounds; and it is very probable that the compound described as myristone, $C_{50}H_{50}O_2$, is identical with that described in this paper as stearene, $C_{28}H_{28}O$, or $C_{56}H_{56}O_2$, the fusing-point of both being nearly the same, viz.: 75° C. myristone, 76° C. stearene.

This investigation was made in the laboratory of Dr. T. Anderson, to whom I am much indebted for advice during its prosecution.

IX.—On deposits of soluble or gelatinous Silica in the lower beds of the Chalk formation.

By J. THOMAS WAY, F.C.S.

CONSULTING CHEMIST TO THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

The author described the discovery which, in conjunction with Mr. J. M. Paine, of Farnham, he had made of large deposits of silica in the condition in which it is readily soluble in solutions of caustic potash or soda when boiled with these solutions at ordinary temperatures in open vessels.

* Chem. Gaz. Nov. 1, 1852.

The beds containing this silica are geologically situate at the base of the chalk formation between the upper green sand and the gault clay. At Farnham, where the beds have been most examined, they are very fully developed, coming to the surface over a considerable breadth of land, and extending to the distance of several miles. Judging from the dip of the strata, and from such sections as the quarries in the neighbourhood afford, the author believes that the total thickness of the deposit in question cannot be at this spot less than from 80 to 100 feet in thickness. It is not, however, of uniform character throughout, but consists of beds of yellowish, light, soft rock, intercalated with loose and apparently sandy marls.

The attention of the author was first drawn to this subject during the examination of a series of specimens representing the strata of the chalk formation, which were collected for analysis about three years ago. On examining some of the lower deposits of this series, he was struck with the circumstance that, though of a yellowish-white colour, of small density, and having every appearance of being chalk marls (under which name they are indeed generally used in agriculture), they did not, in many cases, exhibit the smallest effervescence when treated with an acid, and contained merely a trace of lime in any form.

The following results were obtained from the analysis of a specimen of this earth.

Soluble in acids	{	Silica	40.30
		Peroxide of iron	2.26
		Alumina	3.44
		Lime	.61
		Magnesia	.47
		Chloride of sodium	.14
Insoluble in acids	{	Potash	.43
		Silica	41.23
		Alumina, with a little oxide of iron	11.12
		Traces of lime and magnesia	
			100.00

The silica "soluble in acids" is here the total quantity of silica which is soluble in potash after treatment with boiling muriatic acid in the usual way. The quantity of soluble silica directly dissolved out by potash without previous treatment with an acid, is in this case 28.70 per cent. The author observed that the existence of these beds was not altogether unknown before. Since he had been engaged upon this examination, he had found that similar deposits of

soluble silica had been mentioned by Sauvage, in the *Annales des Mines*, as occurring in the Département des Ardennes, in France. Sauvage had found as much as 56 per cent of soluble silica in these deposits; and from their description it was plain that they were the same beds, although somewhat differing from the corresponding strata in England.

Within the last two years, as many as 80 or 100 samples have been carefully collected by the author and Mr. Paine from the land of the latter at Farnham, and examined in reference to the proportion of soluble silica they contain. In all cases the quantity of soluble silica has been determined by boiling the dry and powdered earth in moderately strong solution of caustic potash or soda, which dissolves the free silica without, as is well known, affecting that portion which is combined with alumina as clay or the silica that may exist as sand.

The quantity of soluble silica so ascertained has been found to constitute from 5 to 72 per cent of the dry earths. As a rule, the deposits which are geologically nearest the gault clay contain the smallest proportion, which increases in the beds as they rise towards the green sand. The largest proportion that has been observed hitherto has been above stated as 72 per cent. This particular bed is at Farnham of about 10 or 12 feet of thickness, and close to the surface of the land on the hill-side. It is very remarkable when dry, on account of its extreme lightness, by which and by its porosity it is easily recognized. Very many of the beds have been found to contain as much as 60 per cent of free soluble silica, and 20 or 30 tons have been sent to London, affording, when ground up, an average amount of 64 per cent. There is therefore no doubt of the beds in question being available as a source of soluble silica if it should be found desirable so to employ them.

The author mentions that although many of the beds contain no carbonate of lime, there are others in which both soluble silica and carbonate of lime are associated. These beds are generally of a harder and more compact character, and are used locally as building-stones. The "firestone," which is quarried to a considerable extent at Godstone and Reigate, in Surrey, and used in London to form the backs of fire-places, is from the same deposit, and of similar composition. Mr. Way has found the building-stone to contain about 25 per cent of soluble silica with 50 per cent of carbonate of lime and 25 per cent of clay.

With the exception of the building and firestone rock, which are of considerable hardness, the other beds are easily reduced to powder;

indeed, when first dug up in the moist state they readily crumble between the fingers. When examined by the microscope the silica is found to be amorphous.

With the exception of a few casts of foraminæ the deposit is not infusorial.

Mr. Way proposes to employ these beds as a source of silicate of lime for agricultural purposes. He finds that the silica can be made to combine with lime with great ease in several ways: a mixture of slaked lime with the powdered rock, when made into a thin mortar, and left for several weeks, is found to be entirely converted into silicate of lime. The process is hastened by adding 2 or 3 per cent of carbonate of soda, which becoming caustic, dissolves the silica, forming a soluble silicate, which is subsequently decomposed by the lime; and in this way, the soda acting as a carrier between them, causes a speedy union between the silica and lime.

Another method of producing the silicate of lime, is to mix the slaked lime with the powdered rock and sufficient water to bring the mixture to the thickness of gruel, and to heat to nearly the boiling-point; the combination is complete in about an hour. In all cases the silica is used in the proportion of 3 equivs. to 1 equiv. of lime.

A mixture of the rock with chalk, when heated to low redness in a reverberatory furnace, gives the compound in a very fit condition for agricultural use; but it is necessary that the heat should be carefully regulated, otherwise the silicate becomes altogether insoluble in water.

The author has found silicate of lime produced in either of the above ways soluble to the extent of about 20 grains in the gallon of distilled water; and as the largest portion of the 20 grains so dissolved is silica, he considers this solubility sufficient in relation to the quantity of water passing through plants, to supply all the silica required by wheat, barley and other plants of the silicious class.

He proposes to employ the silicate of lime as a manure for light lands, and he anticipates that it will serve to correct the over-luxuriance and tendency to be "laid," which is so common in well-manured light soils, and that it will render the use of guano and other nitrogenous manures more certain and more admissible on such lands.

Mr. Way, in conclusion, suggests a possible connection between the existence of these beds and the production of the chalk itself. He thinks it certain that the deposits of soluble silica can only have been formed from solution and in the absence of heat. Silicate of lime, derived by disintegration from the older rocks, many of which contain it in abundance and dissolved in water, may be supposed to

be acted upon by carbonic acid derived from the decomposition of animal and vegetable matter or from volcanic sources. The results of such an action would be the production both of carbonate of lime and of soluble silica. The author points out as an interesting fact, that we not only find the chalk closely associated with the silica beds, but that in the case of the building and firestone before described, they are in some cases intimately mixed, which could hardly have occurred if the two deposits were not due to some common origin.

X.—*On a Compound Sulphate of Potash and Soda.*

BY J. H. GLADSTONE, Ph.D., F.R.S., F.C.S.

The saturating power of the common organic acids, is a subject to which great attention has been and still is paid. Many acids that were once considered monobasic have had their equivalents doubled or trebled, with evident advantage in the explanation of their salts. To take one example: Tartaric acid, formerly viewed as $\text{HO}, \text{C}_4\text{H}_2\text{O}_5$, is now represented as $2 \text{HO}, \text{C}_8\text{H}_4\text{O}_{10}$, and its bibasic character explains at once why, if half the quantity of potash necessary for its saturation be added to a solution of the acid, we obtain not a mixture of neutral salt and free acid, but a sparingly soluble bitartrate; and why we have such an endless variety of double tartrates, even one, Rochelle salt, in which the two alkalies, potash and soda, are united, although they are bases of the same natural family.

Chemists have more recently been led to inquire whether some of the inorganic acids usually esteemed monobasic, should not be also viewed as bibasic. It has been well remarked, that whilst some acids—as, for instance—nitric acid, always form neutral simple salts, others, of which sulphuric acid may be taken as a type, exhibit a great tendency to form acid and double salts. In fact, every reason which could be urged in favour of the bibasic character of tartaric acid would equally apply to sulphuric acid, excepting that we have no compound analogous to Rochelle salt. The argument is perhaps sufficiently strong even now; but could a double sulphate of potash and soda be prepared, the analogy would be complete; and none, I apprehend, who are accustomed to double the formula of tartaric acid, could refuse to view sulphuric acid also as $2 \text{HO}, \text{S}_2\text{O}_6$.

It was in the attempt to obtain such a salt that the compound now to be described was discovered.

Having occasion to prepare some salt which should show flashes of light on crystallizing, I followed the method recommended in Gmelin's "Handbook of Chemistry," Vol. I, p. 207. 2 parts of sulphate of potash, and 1 part of chloride of sodium, were fused together; the mass, removed from the crucible, was dissolved in boiling water, filtered, and suffered to cool. The result was very satisfactory. Small crystals separated, each at its formation emitting a luminous flash, visible even in shaded daylight. Their appearance struck me as being very uniform, yet certainly not that of sulphate of potash; and it occurred to me that they might be a double sulphate of the two alkalis. The crystals were examined by Mr. Crosby, of St. Thomas's Hospital, and were found to contain no water, but to give a precipitate with antimoniate of potash. They consisted of about 48 per cent of sulphuric acid, and 47 per cent of potash; the remaining 5 per cent, or thereabouts, being soda. This was quite inconsistent with the formula $\text{KO}, \text{NaO}, \text{S}_2\text{O}_6$; but it might well contain such a compound, mixed with ordinary sulphate of potash.

A series of experiments was set on foot in order to obtain, if possible, pure crystals of this supposed salt. The salts obtained were freed from hygroscopic moisture by heating them; sulphuric acid was determined in the usual way as baryta-salt, and the potash as platinum-salt. Every analysis that was made by me is recorded.

Exp. 1. A crop of large crystals was obtained by the process already described. They were very regular in form—six-sided prisms, terminating in six-sided pyramids, truncated.

Salt employed.	Sulph. baryta obtained.
38·18 grs.	53·10 grs.
27·61 „	38·65 „
Salt employed.	Chlor. plat. and pot. obtained.
13·83 grs.	33·32 grs.

The acid and base thus determined are in the proportion :

Sulphuric acid	47·77	and	48·06	per cent
Potash . . .	46·58			„

Now, in order to obtain such numbers as these, we must suppose that 6 equivs. of sulphuric acid are combined with 5 of potash and 1 of soda.

	Equivs.	Calculated.	Average of experiments.
Sulphuric acid	6	47·26	47·91
Potash . . .	5	46·57	46·58
Soda . . .	1	6·16	5·34
		100·00	100·00

Exp. 2. One part of sulphate of potash was mixed with two parts of crystallized sulphate of soda, that is, about equivalent proportions; water was expelled from the mixture by heat, and the salts were fused together. The cooled mass was dissolved in hot water, which presently afforded crystals similar in appearance to the preceding. They were dried and analyzed.

Salt employed.	Salt obtained.
32·64 grs.	45·60 grs. sulph. of baryta.
14·65 „	35·81 „ chlor. plat. pot.

These numbers indicate :

Sulphuric acid	47·96 per cent
Potash . . .	47·26 „

This salt is evidently identical with the preceding.

Exp. 3. One part of sulphate of potash and two parts of crystallized sulphate of soda were dissolved together in water by the aid of heat. There separated on cooling, small crystals, of a perfectly definite appearance, six-sided prisms with six-sided pyramids at the ends, truncated. They were analyzed as before.

Salt employed.	Salt obtained.
10·20 grs.	14·41 grs. sulph. baryta.
8·31 „	19·31 „ chlor. plat. pot.

These numbers indicate :

Sulphuric acid	48·49 per cent
Potash . . .	44·92 „

These results differ but little from those previously obtained.

Exp. 4. A mixture of *equal* parts of sulphate of potash and chloride of sodium fused together and dissolved in hot water, afforded crystals which were evidently the same.

Exp. 5. Three parts of bisulphate of potash and one part of chloride of sodium were fused together. Hydrochloric acid was given off in large quantity, as might be expected; and on dissolving the fused mass in hot water, and suffering it to cool, there separated

hexagonal crystals, apparently identical with those previously examined, mixed with another salt in feathery flakes.

Exp. 6. The same salts, mixed in the same proportions, were boiled together for a considerable time in water. The solution yielded the feathery flakes above mentioned, along with crystals that appeared to be thin segments of hexagonal prisms, but which Dr. Leeson, by a minute examination of their angles, found to be derived from the octagon of the regular system by the development of two of the opposite planes. They were found to contain soda, and no water. On analysis, they yielded the following results :

Salt employed.	Salt obtained.
25·09 grs.	35·12 grs. sulph. baryta.
14·17 „	33·20 „ chlor. plat. pot.

which indicate :

Sulphuric acid	48·05 per cent
Potash . . .	45·29 „

As the microscope showed some small needle-shaped crystals sticking to these octagonal ones, a portion of the salt was washed several times with a very little cold water, and analyzed.

Salt employed.	Salt obtained.
7·51 grs.	10·37 grs. sulph. baryta
6·00 „	14·22 „ chlor. plat. pot.

which indicate :

Sulphuric acid	47·40
Potash . . .	45·83

Another portion of salt was prepared from the same source, recrystallized, and then washed with a little cold water. The crystals were small, but of the same form as the first. They were analyzed.

Salt employed.	Salt obtained.
21·46 grs.	29·61 grs. sulph. baryta
7·23 „	17·49 „ chlor. plat. pot.

which indicate :

Sulphuric acid	47·37 per cent
Potash . . .	46·75 „

All these results seem to point out a salt similar in composition to all those previously examined.

Exp. 7. A saturated solution of carbonate of soda was added to a saturated solution of bisulphate of potash until effervescence ceased.

A crystal or two separated. The solution yielded on evaporation a crop of crystals, bearing a general resemblance to the salt formerly obtained. They were dried and analyzed.

Salt employed.	Salt obtained.
24.42 grs.	33.95 grs. sulph. baryta
12.06 „	27.40 „ chlor. plat. pot.

which indicate :

Sulphuric acid	47.73 per cent
Potash . . .	43.92 „

differing little from previous estimations.

Exp. 8. One part of nitrate of potash and two parts of crystallized sulphate of soda, dissolved together, and evaporated, gave crystals of the compound salt, mixed with nitre.

Exp. 9. In order to see whether the same salt would form in the presence of a large excess of acid, 3 ounces of sulphate of potash, 6 ounces of crystallized sulphate of soda, and nearly 2 fluid ounces of sulphuric acid, were boiled together in water, and evaporated. The crystals, which were small, and of the ordinary shape, were slightly washed with cold water, dried, and analyzed.

Salt employed.	Salt obtained.
27.78 grs.	39.17 grs. sulph. baryta,

which indicates :

Sulphuric acid . .	48.40 per cent.
--------------------	-----------------

This scarcely exceeds the previous determinations of sulphuric acid. The salt was evidently the same.

Exp. 10. Conversely, the effect of an alkaline solution was tried. Two parts of sulphate of potash and one part of hydrate of soda were dissolved together in water. The evaporated solution gave a crop of very minute crystals. They were washed with a little cold water two or three times, dried over sulphuric acid, and analyzed.

Salt employed.	Salt obtained.
18.39 grs.	25.61 grs. sulph. baryta,

which indicates :

Sulphuric acid . .	47.81 per cent.
--------------------	-----------------

Hence the salt was identical with those analyzed before.

Exp. 11. Thinking that a large excess of soda might cause the formation of a salt richer in soda, 6 parts of that sulphate, crystallized, were dissolved in water with 1 part of sulphate of potash, and evaporated. Crystals of common sulphate of soda alone separated.

On another occasion, when 1 lb. of sulphate of soda had been dissolved along with $\frac{1}{2}$ lb. of sulphate of potash, the solution yielded, first, six-sided prisms, with dihedral summits, containing soda; then large crystals of sulphate of soda; and the mother-liquor from them yielded again a crop of the compound salt.

It appears, then, that all these attempts have failed to produce a sulphate of potash and soda analogous to the double tartrate; but they invariably yielded a compound salt containing a small amount of soda. This has all the appearance of being definite and uniform, and seems to consist of sulphuric acid, combined with 6 equivs. of base, 1 being soda and 5 potash. Its formula decides nothing in favour of the bibasic character of sulphuric acid, but it does not militate against such a view: it may be written $5\text{ KO}, \text{NaO}, 3\text{ S}_2\text{O}_6$, though perhaps chemists will generally prefer the expression $5(\text{KO}, \text{SO}_3) + \text{NaO}, \text{SO}_3$.

It may be asked, why was not the salt subjected to repeated crystallizations before it was analyzed? The reason was, that I feared some alteration in the salt during such a process; indeed, a specimen which had thus been treated, was found to have lost 1 per cent of sulphuric acid, showing a considerable decrease in the amount of soda.

Salt employed.	Salt obtained.
26·11 grs.	35·38 grs. sulph. baryta.
25·05 „	34·08 „

which indicate :

Sulphuric acid, 46·52 and 46·70 per cent.

Had the salt been entirely reduced to ordinary sulphate of potash, analysis should have given only 45·94 per cent.

The solubility of this compound salt was found to be very similar to that of sulphate of potash itself: 1000 parts of water at $21\cdot2^\circ\text{ F}$. were found capable of dissolving 250 parts; at 55° F ., 101 parts; and at 40° F ., 92 parts of the salt. 25 grs. of salt, recrystallized during this experiment, was found to yield 34·11 grs. of sulphate of baryta, indicating 46·90 per cent of sulphuric acid.

The crystalline form, also, is the same as that of sulphate of potash; but the crystals appeared to me more uniform than that salt ordinarily is, and having not so great a tendency to become long and branching. The compound and the simple salt are both alike anhydrous.

Since performing these experiments, I have consulted the original paper of Rose, in Pogg. LII, "*Ueber die Lichterscheinungen bei*

der Krystallbildung." I find he has accurately described the crystals which emit light, but his quantitative determinations led him to doubt their definite character; I, however, have always found them uniform in composition, in whatever manner they may have been produced. Their production, indeed, under such various circumstances, could not have been anticipated; and they form a remarkable instance of a certain proportion of the base of a salt being replaced by an analogous oxide, without materially affecting its physical properties.

XI.—*Note on Thierschite.*

BY J. LIEBIG.

(FROM A LETTER TO DR. HOFMANN.)

Some time ago, I received from Dr. F. von Thiersch, General Conservator of the scientific collections of Bavaria, a fragment of a white marble column from the Parthenon, for the purpose of analyzing the incrustation with which the external surface of the column was covered, the chief object of the examination being to decide whether the column had been painted with a colour of a still determinable nature.

The incrustation was about $\frac{1}{10}$ of an inch thick, and possessed the hardness of fluor-spar. Under the microscope, when illuminated by sun-light, it appeared as a lustrous, opaline aggregate of warty nuclei, exhibiting a concentric structure. When seen by the naked eye, it appeared an uneven layer of a dingy-grey colour, covering the whole outer surface of the stone.

A portion of the detached crust dissolved in acetic acid with effervescence; the solution contained nothing but lime. The greater portion was insoluble in acetic acid, but was readily dissolved by nitric acid, only a trifling residue remaining behind.

The nitric solution gave, upon addition of ammonia, a snow-white precipitate, insoluble in ammonia. After addition of acetate of soda, it furnished, with salts of silver and lead, a white precipitate. This deportment pointed towards oxalic acid, and indeed a more minute examination soon convinced me that the chief mass of the incrustation, which had been taken for a pigment used in painting the column, consisted of crystallized oxalate of lime.

I treated the precipitate produced by ammonia in the nitric

solution with chloride of copper, which converted it into a bluish powder, whilst the lime was dissolved. The copper precipitate dissolved readily in ammonia; and this solution yielded, after the copper had been thrown down, a beautiful crystallization of oxalate of ammonia which was decomposed, without deposition of carbon, into carbonic acid and carbonic oxide when heated with concentrated sulphuric acid, and from which oxalic acid, with all its properties, was prepared in sufficient quantity for an analysis, if such had been considered necessary.

Dr. Sendtner, Adjunct to the Botanical Gardens in Munich, who has a great deal of experience in researches of this kind, was unable to discover any organic structure, either in the incrustation itself or in the residue insoluble in nitric acid. I believe, therefore, I am justified in considering this incrustation, which will probably be found upon many lime-stones, as a mineral species; and since Sandall has observed crystallized oxalate of lime between metastatic calc-spar crystals in Hungary, without proposing a mineralogical name for it, I have great pleasure in coupling with this mineral the name of the learned man whose labours have so successfully contributed to the elucidation of antiquities, and who has given rise to the present observations.

The origin of this oxalate of lime can scarcely be doubtful; it is evidently derived from lichens vegetating upon the lime-stone; it is the residue of a series of generations, following each other during centuries, until the whole surface of the stone—in consequence of the gradual destruction of former vegetations, whose organic matter decayed, while the oxalate of lime produced during their vitality remained unaltered—was so completely covered, that new germs of lichens no longer found the soil of carbonate of lime necessary for their development. The residue of the incrustation, insoluble in nitric acid, when heated in a glass tube, was slightly charred; it contained traces of a humus-like substance, evidently the last residue of the lichens, protected by the oxalate of lime from entire destruction.

XII.—On *Kyanurenic Acid*.

By J. LIEBIG.

(FROM A LETTER TO DR. HOFMANN).

During some experiments made by Professor Bischoff, regarding the amount of uric acid in dog's urine, the latter was very frequently

examined for uric acid. In no case could a trace of this acid be detected.

During these researches, the urine deposited sometimes, but not very frequently, a precipitate which, on account of its minute divisions, was difficult to filter. An examination of this deposit has proved that it consists chiefly of a new acid which I propose to call *kyanurenic acid*, in order to remind us of its origin.

On dissolving the coloured deposit of dog's urine in lime-water, diluting with water, and adding hydrochloric acid to the gently warmed liquid, kyanurenic acid separates in delicate colourless needles which, on drying, become very light, and assume a satiny lustre; they redden blue litmus-paper. From concentrated solutions the acid is deposited in the form of a powder. When heated in a glass tube, the acid fuses to a brown liquid which on further application of heat sublimes, a trace of charcoal remaining behind. The sublimate is white satiny lustrous crystalline; it dissolves in alcohol, and differs by this deportment from the original acid. Kyanurenic acid may be readily distinguished from uric acid by its solubility in hydrochloric acid; the precipitate which is produced in alkaline solutions of the acid, upon addition of hydrochloric acid, disappears again, if an excess be added. It dissolves readily in boiling hydrochloric acid, and in dilute sulphuric and nitric acid; in the latter, apparently without decomposition. Its hot saturated solutions solidify, upon cooling, to a magma of short, extremely lustrous needles. In cold concentrated sulphuric acid, kyanurenic acid dissolves without change; on gently warming, the solution assumes a light-brown colour, and now deposits, upon addition of water, a beautiful lemon-yellow, amorphous precipitate which is sometimes mixed with crystals of unchanged acids. Kyanurenic acid readily dissolves in the caustic, and, upon application of heat, also in the carbonated alkalies, also in lime- and baryta-water; when employed in sufficient quantity, it perfectly destroys their alkaline reaction. Evaporation of these solutions yield well crystallized salts. The lime-salt forms stellar groups of short hard needles; the baryta-salt, feather-like, united leaflets, exhibiting the lustre of mother-of-pearl: both salts are difficultly soluble in water. A solution of the acid in ammonia furnishes, upon addition of nitrate of silver, a dense, white precipitate, insoluble in hot water.

I have abstained from sacrificing to an elementary analysis the small portion of this substance which I had at my disposal, inasmuch as the composition of this body which seems to occur but rarely, and in small quantities, appeared to me less important than the

proof of its existence, and the study of those properties by means of which it may be readily recognized again. According to the experiments which I have made, kyanurenic acid contains no nitrogen, or only so small a quantity that the minute portions which I was able to devote to the experiments were insufficient to show its presence.

XIII.—*Analysis of the Waters from the Deep Wells of Westbourne Park and Russell Square, and the Artesian Well of the Hamwell Lunatic Asylum.*

BY CHARLES HARWOOD CLARKE, ESQ., B.A., F.S.A., AND
HENRY MEDLOCK, ESQ., F.C.S.

The deep well of Westbourne Park is situated a short distance to the north of Westbourne Grove. It was sunk several years since by J. W. Treeby, Esq., for the purpose of supplying the houses on his private estate. The surface of the ground in the neighbourhood is 73·5 feet above the Ordnance datum line. The depth of the well is 230 feet, and the water rises to within 120 feet of the surface. It is sunk through various strata of sand and clay, and a bore-pipe carried to a depth of 15 feet into the chalk. The supply of water is derived from two strata, the chalk, and the sand immediately above it. The samples for analysis were collected in December, 1852, the one (*A*) being taken from the well, and the other (*B*) from the bore-pipe which leads into the chalk. Both specimens were bright and colourless, and possessed an agreeably refreshing but slightly saline taste.

At the time the water was collected, the bore-pipe had been closed, and the sample (*A*) was considered as being derived exclusively from the sand strata immediately above the chalk.

The quantitative analysis yielded the following results :

A. Determination of the total quantity of fixed constituents.

Water employed.	Residue obtained (dried at 120° C. = 248° F.)	Percentage.
44520 grs.	36·3744 grs.	0·081703

B. Determination of organic matter.

Water employed.	Organic matter expelled at a dull red heat.	Percentage.
44520 grs.	0·4573 gr.	0·001027

C. Determination of silicic acid.

Water employed.	Silicic acid obtained.	Percentage.
44520 grs.	0·4152 gr.	0·000932

D. Determination of iron, alumina and phosphates.

Water employed.	Precipitate obtained.	Percentage.
44520 grs.	0·2185 gr.	0·000490

E. Determination of lime.

Water employed.	Carbonate of lime obtained.	Percentage of lime.
44520 grs.	2·2246 grs.	0·002798

F. Determination of magnesia.

Water employed.	Pyrophosphate of magnesia obtained.	Percentage of magnesia.
44520 grs.	1·7817 grs.	0·001451

G. Determination of chlorine.

Water employed.	Chloride of silver obtained.	Percentage of chlorine.
70000 grs.	43·4695 grs.	0·015351

H. Determination of sulphuric acid.

Water employed.	Sulphate of baryta obtained.	Percentage of sulphuric acid (SO ₃).
70000 grs.	39·0852 grs.	0·019170

I. Determination of alkalies.

Water employed.	Mixed chlorides obtained.
70000 grs.	46·4693 grs.

a. Determination of potassium.

Water employed.	Bichloride of platinum and chloride of potassium obtained.	Percentage of potassium.
70000 grs.	55·0502 grs.	0·012559

b. Determination of sodium.

Water employed.	Chloride of sodium obtained.	Percentage of sodium.
70000 grs.	29·6747 grs.	0·016667

J. Determination of carbonic acid :

In order to obtain a perfectly fresh sample of the water for the determination of the carbonic acid, the well was pumped nearly to dryness and the water collected as it issued rapidly from the strata of sand. A bottle containing ammonia and solution of chloride of calcium, and capable of holding in addition 70000 grs. of water, was

filled, and the precipitated carbonate of lime subsequently determined.

Water employed.	Precipitate of carbonate of lime obtained.	Percentage of carbonic acid.
70000 grs.	39·0909 grs. containing 17·2004 grs. of carbonic acid.	0·024572

The second sample of water (*B*) was taken from the bore-pipe which passes to a depth of 15 feet into the chalk, and was supposed to be derived exclusively from the chalk strata below the sand. The following results were obtained by quantitative analysis.

A. Determination of the total quantity of the fixed constituents.

Water employed.	Residue obtained (dried at 120° C. = 248° F.)	Percentage.
44520 grs.	36·0498 grs.	0·080973

B. Determination of organic matter.

Water employed.	Organic matter expelled at a dull red heat.	Percentage.
44520 grs.	0·6683 gr.	0·001500

C. Determination of silicic acid.

Water employed.	Silicic acid obtained.	Percentage.
44520 grs.	0·3003 gr.	0·000673

D. Determination of iron, alumina and phosphates.

Water employed.	Precipitate obtained.	Percentage.
44520 grs.	0·3973 gr.	0·000892

E. Determination of lime.

Water employed.	Carbonate of lime obtained.	Percentage of lime.
44520 grs.	2·1364 grs.	0·002710

F. Determination of magnesia.

Water employed.	Pyrophosphate of magnesia obtained.	Percentage of magnesia.
44520 grs.	1·4630 grs.	0·001191

G. Determination of chlorine.

Water employed.	Chloride of silver obtained.	Percentage of chlorine.
44520 grs.	26·5804 grs.	0·014755

H. Determination of sulphuric acid.

Water employed.	Sulphate of baryta obtained.	Percentage of sulphuric acid (SO ₃).
44520 grs.	23·9932 grs.	0·018502

I. Determination of alkalies.

Water employed.	Mixed chlorides obtained.
44520 grs.	28·9235 grs.

a. Determination of potassium.

Water employed.	Bichloride of platinum and chloride of potassium obtained.	Percentage of potassium.
44520 grs.	37·3976 grs.	0·013415

b. Determination of sodium.

Water employed.	Chloride of sodium obtained.	Percentage of sodium.
44520 grs.	17·5143 grs.	0·015467

J. Determination of carbonic acid.

The water was taken direct from the bore-pipe, and introduced immediately into the bottle containing ammonia and chloride of calcium.

Water employed.	Precipitate of carbonate of lime obtained.	Percentage of carbonic acid.
70000 grs.	38,8218 grs. containing 17·0816 grs. of carbonic acid.	0·024402

The deep well in Russell Square is situated on the north side of the square. The surface of the ground is 82 feet above the Ordnance datum line. The well is sunk through the sand, and a bore-pipe carried to a depth of 100 feet into the chalk. The total depth of the well is 230 feet, and the water rises to within 130 feet of the surface, differing in height only by a few inches from the level of the water in the well at Westbourne Park.

The sample for analysis was collected in December, 1852, and gave the following results :

A. Determination of the total quantity of fixed constituents.

Water employed.	Residue obtained (dried at 120° C = 248° F.)	Percentage.
44520 grs.	30·3701 grs.	0·068213

B. Determination of organic matter.

Water employed.	Organic matter expelled at a dull red heat.	Percentage.
44520 grs.	0·5005 gr.	0·001098

C. Determination of silicic acid.

Water employed.	Silicic acid obtained.	Percentage.
44520 grs.	0·5112 gr.	0·001148

D. Determination of iron, alumina, and phosphates.

Water employed.	Precipitate obtained.	Percentage.
44520 grs.	0·1694 gr.	0·000380

E. Determination of lime.

Water employed.	Carbonate of lime obtained.	Percentage of lime.
44520 grs.	14·3220 grs.	0·001801

F. Determination of magnesia.

Water employed.	Pyrophosphate of magnesia obtained.	Percentage of magnesia.
44520 grs.	0·5852 gr.	0·000472

G. Determination of chlorine.

Water employed.	Chloride of silver obtained.	Percentage of chlorine.
44520 grs.	20·0015 grs.	0·011106

H. Determination of sulphuric acid.

Water employed.	Sulphate of baryta obtained.	Percentage of sulphuric acid (SO_3).
44520 grs.	19·7274 grs.	0·015213

I. Determination of alkalis.

Water employed.	Mixed chlorides obtained.
44520 grs.	26·2831 grs.

a. Determination of potassium.

Water employed.	Bichloride of platinum and chloride of potassium obtained.	Percentage of potassium.
44520 grs.	20·7468 grs.	0·007458

b. Determination of sodium.

Water employed.	Chloride of sodium obtained.	Percentage of sodium.
44520 grs.	19·9537 grs.	0·017620

J. Determination of carbonic acid.

Water employed.	Carbonate of lime obtained.	Percentage of carbonic acid.
50640 grs.	~ 26·9546 grs. containing 11·8600 grs. of carbonic acid	0·023420

The artesian well at Hanwell is sunk near to, and supplies the Asylum. The depth of the well is 235 feet, and the water rises to a height of 36 feet above the surface, the level of the ground being 74·5 feet above the Ordnance datum line.

The sample submitted to analysis was collected in February last, and gave the following results :

A. Determination of the total quantity of fixed constituents.

Water employed.	Residue obtained (dried at 120°C = 248° F.)	Percentage.
44520 grs.	30·4350 grs.	0·068514

B. Determination of organic matter.

Water employed.	Organic matter expelled at a dull red heat.	Percentage.
44520 grs.	1·1473 grs.	0·002719

C. Determination of silicic acid :

Water employed.	Silicic acid obtained.	Percentage.
44520 grs.	0·1155 gr.	0·000259

D. Determination of iron, alumina and phosphates :

Water employed.	Precipitate obtained.	Percentage.
44520 grs.	0·2046 gr.	0·000459

E. Determination of lime :

Water employed.	Carbonate of lime obtained.	Percentage of lime.
44520 grs.	3·2725 grs.	0·00411

F. Determination of magnesia :

Water employed.	Pyrophosphate of magnesia obtained.	Percentage of magnesia.
44520 grs.	3·9270 grs.	0·003196

G. Determination of chlorine :

Water employed.	Chloride of silver obtained.	Percentage of chlorine.
44520 grs.	15·4693 grs.	0·008588

H. Determination of sulphuric acid :

Water employed.	Sulphate of baryta obtained.	Percentage of sulphuric acid (SO ₃).
44520 grs.	19·7967 grs.	0·015266

I. Determination of alkalis :

Water employed.	Mixed chlorides obtained.
44520 grs.	22·2607 grs.

a. Determination of potassium :

Water employed.	Bichloride of platinum and chloride of potassium obtained.	Percentage of potassium.
44520 grs.	35·8204 grs.	0·012845

b. Determination of sodium :

Water employed.	Chloride of sodium obtained.	Percentage of sodium.
44520 grs.	11·3328 grs.	0·008666

J. Determination of carbonic acid :

Water employed.	Carbonate of lime obtained.	Percentage of carbonic acid.
50640 grs.	33·6767 grs. containing 14·8177 grs. of carbonic acid.	0·029605

From the above analyses we have deduced the following results: In Table I, the constituents, as found by analysis, are given separately, and in Table II, the acids and bases are associated in the usual manner:

TABLE I.

	Westbourne water.		Russell Square water.	Hanwell water.
	A. Sand.	B. Chalk.		
	Grains in an imperial gallon.			
Lime	1·9588	1·8972	1·2611	2·8813
Magnesia	1·0159	0·8341	0·3307	2·2376
Potassium	8·7918	9·3909	5·2096	8·9919
Sodium	11·6670	10·8271	12·3342	6·0665
Iron, alumina and phosphates	0·3430	0·6247	0·2663	0·3217
Sulphuric acid (SO ₃)	13·4195	12·9514	10·6491	10·6861
Chlorine	10·7461	10·3287	7·7746	6·0121
Carbonic acid	17·2004	17·0816	16·3941	20·4824
Silicic acid	0·6529	0·4712	0·8037	0·1817
Organic matter	0·7191	1·0502	0·7690	1·8033

TABLE II.

	Westbourne water.		Russell Square water.	Hanwell water.
	A. Sand.	B. Chalk.		
	Grains in an imperial gallon.			
Carbonate of lime	3·4978	3·3878	2·2519	5·1451
„ „ magnesia	2·1223	1·7425	0·6908	4·6746
Chloride of sodium	17·7083	17·0205	12·8116	9·9072
Sulphate of soda	8·2148	5·7733	9·4181	2·5980
Carbonate of soda	4·7100	5·2200	9·7261	3·0642
Sulphate of potassa	19·1220	21·0949	11·6213	20·0590
Silicic acid	0·6529	0·4712	0·8037	0·1817
Iron, alumina and phosphates	0·3430	0·6247	0·2663	0·3217
Organic matter	0·7191	1·0502	0·7690	1·8033
Total	57·0895	56·3851	48·3588	47·7548
Solid residue obtained on evaporation	57·1927	56·6812	47·7511	47·9600
Free carbonic acid (grains in a gallon)	12·5830	12·5185	11·0060	12·7174
Free carbonic acid (in cubic inches at 44° F.)	25·1660	25·0370	22·0120	25·4348
Degree of hardness, Clark's) before boiling	6°·5	5°·6	4°·3	12°·1
scale) after boiling	0°·7	0°·5	0°·9	1°·4

A striking feature in the foregoing analyses is the almost complete identity of the water from the sand and that from the chalk in the well at Westbourne Park. This circumstance proves that the so-called chalk-water supply to the deep wells of London is not entirely confined to that stratum.

The great similarity between the Westbourne and Russell Square waters, and the levels at which they stand in the wells being the same, show that both wells are supplied by the same water-stratum. These waters also agree very closely in composition with the water of Trafalgar Square.*

On comparing the analysis of the Hanwell water with those of the deep well-waters of London, the difference between them is comparatively trifling, showing an evident connection between them, notwithstanding the great difference of level at which the Hanwell water stands as compared with the wells of London. This would seem to indicate the existence of a basin to the west of London, the water in which stands at a much higher level than the water under London, and from the overflowing of which the deep wells of the metropolis derive a considerable portion of their supply. We are indebted for this suggestion to Mr. Henry Marten, who examined the district for the West London Water Works Company.

The analyses hitherto made of the deep well-waters of London and the neighbourhood, are not sufficiently numerous to admit of any definite conclusion being drawn as to the probable sources of the water supply. We have been induced, however, to communicate the results of our analyses to the Society as an additional contribution to a knowledge of the deep well-waters of London.

XIV.—*On the increase in Weight of Molasses casks occasionally arising from Absorption.*

BY WILLIAM FERGUSON, ESQ., F.C.S.

In September, 1851, attention was attracted to an unusual increase of weight in a shipment of molasses, which occurred in the London Docks; it was some time before the cause could be discovered, and the steps taken to ascertain it ended in the perfect assurance that it

* Quart. Journ. Ch. Soc. I, 97.

was due to absorption. The great extent to which the action had taken place, and the large amount of property in our dock warehouses which is thus proved to be occasionally affected by it, lead me to believe that a detailed account of this extraordinary instance may prove acceptable to the Society. For the following particulars I am indebted to Mr. Muggeridge, of the London Docks, in whose care the molasses were stored, and by whom the progress of the action was watched.

In August, 1849, a quantity of molasses were housed for the first time in a damp cellar, where they lay until September, 1851, when the increase of weight was observed. In order to ascertain its amount, the whole of the casks of the importation were re-weighed, when it was found that every cask which had not lost a portion of its contents by breakage, had gained considerably in weight. The casks were coopered and made tight, and in February, 1852, were again weighed, when (where breakage had not occurred) a further increase was found to have taken place. The total weight of the shipment was 1270 cwt. It was stored in 110 casks, containing from 11 to 12 cwt. each. The increase on different casks varied considerably, reaching in some cases 38 lbs. or about 3 per cent of the contents. The total observed increase was $23\frac{1}{4}$ cwt., or about 1.83 per cent. This does not represent the total real increase, for it would appear that in some casks the absorbed water had just been sufficient to cover the loss from breakage, but not tell as increase; and there does not seem to have been one cask which had not suffered more or less loss. The real increase of weight due to absorption must have been much greater than that shown by the weighings. Important as this result was to the merchant, it was greatly exceeded by one that was afterwards observed, and which was as follows. A quantity of molasses imported in large tanks were, in July, 1849, racked into 347 puncheons, weighing about 12 cwt. each, the total weight being 4160 cwt.; they were stowed in a lofty cellar, where they remained till September, 1852, when they were re-weighed for delivery. At various times some of the casks were found with heads bulging out from internal pressure, although none of them were full when housed, and it was necessary to draw off a portion to prevent them from bursting. When the bung was started, the molasses rushed out with great force, ascending several feet to the roof of the cellar. On re-weighing, the increase was, as before, found to be different in different casks. On 52 there was a loss from breakage, 248 had gained from 1 lb. to 30 lbs. each, 67 from 30 lbs. to 40 lbs., and 20

from 40 lbs. to 51 lbs. each. The total increase of weight on the shipment was 56 cwt. If we take the casks on which this increase took place, laying aside the 52 on which there was loss, the excess of absorbed water over the leakage was about 1·6 per cent; in some of the casks it had reached as high a percentage as 4·25. A third case was also observed in December, 1848. 500 puncheons were filled from tanks in which they had been imported, and stored in the same cellar till July, 1852, when some of them were re-weighed with the same various results as to increase: 5 puncheons gave the following results:

No.	1,	weight	11	3	13	lbs.	gained	23	lbs.
„	2,	„	11	1	7	„	„	31	„
„	3,	„	12	0	7	„	„	40	„
„	4,	„	11	2	0	„	„	45	„
„	5,	„	12	0	0	„	„	68	„

This was the largest increase of weight, though on a large number of casks it reached nearly to the same percentage. In No. 5 the excess of water absorbed over any leakage that may have occurred is 5 per cent. The bungs were at this time started, and the casks, which had been stored not quite full, were found full to overflowing. One cask which had lost 14 lbs., and another 9 lbs., were also full. We know that these casks had not been overdrawn. Now, to effect a loss of 14 lbs., 4 gallons of treacle must have been replaced by water, not taking into account the quantity which was required to fill the cask completely. In the case of No. 5, where the increase of weight was 68 lbs., the quantity of water absorbed must have been very great, for after supplying the loss due to leakage, (and all casks leak more or less), 6·8 gallons of water entered through the pores of the wood during a period of $3\frac{1}{2}$ years. These puncheons, in which this maximum effect took place, had been American meal-casks, made of Quebec timber, which is much more porous than the wood of which West India puncheons are usually made. The specific gravity of the freshly-imported molasses of the last lot was 1·394, and when taken in July, 1852, was 1·375.

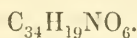
XV.—*On some New Basic Products obtained by the Decomposition of Vegetable Alkaloids.*

By HENRY HOW, Esq., F.C.S.

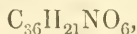
ASSISTANT TO PROFESSOR ANDERSON, OF GLASGOW.

In the following pages, I purpose submitting to the notice of the Society the results of some experiments, so far as I have proceeded with them, on the action of the halogen-compounds of the alcohol radicals on bases of vegetable origin. The beautiful researches of Hofmann on the behaviour of artificial liquid bases and of ammonia, under these circumstances, led him to remark that a similar course of investigation, in regard to basic substances generally, would no doubt tend to throw much light on the nature of these bodies. On comparing the formulæ of some of the vegetable alkaloids with which I was best acquainted, their relations to each other were such that I was curious to bring to light the result of experimenting upon some of these substances in the direction mentioned.

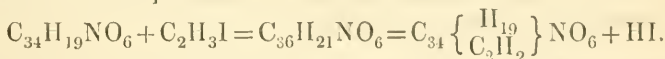
The established formula for morphia, which was first given as the correct interpretation of the analysis of the pure alkaloid by Laurent,* and which I have confirmed by experiments of my own, is



It will be seen, by a comparison of this formula with that of codeine, as established beyond a doubt by Professor Anderson,†



that these alkaloids differ from each other exactly by C_2H_2 . Now, reasoning from analogy, if these bases follow the same laws of decomposition as their volatile congeners, I should, by the action of iodide (*e. g.*) of methyl upon morphia, obtain either codeine or a base having the same centesimal composition, according to the reaction expressed in the equation :



It was with this idea that I commenced the following series of experiments; and although the reaction represented above was not that which I studied first—for iodide of ethyl was ready to my hand—the results which I obtained with this compound, though not such as to render me sanguine as to the actual conversion of the one

* Ann. Ch. Phys. [3], XIX.

† Trans. Roy. Soc. Edinb. XX, I, 57.

alkaloid into the other—a problem which has engaged the attention of chemists of great name*—were sufficiently marked in character to urge me to prosecute the inquiry, with what success will be seen in the sequel.

If, in the succeeding pages, the numbers given in one or two instances fall somewhat below the standard of accurate analytical proof, I trust that, to those acquainted with the nature of the materials employed, the mention of their costly character will be sufficient excuse for a want of repetition of experiments where a great deal would not have been gained by the same; believing that sufficient evidence is furnished as to the composition at least of the substances produced. I beg here to offer my most sincere thanks to Professor Anderson, in whose laboratory, attached to the University of Glasgow, my experiments were performed, for the opportunity of conducting this inquiry.

In detailing the investigation, I have preferred to narrate the individual reactions, &c., in the order in which they were examined.

ACTION OF IODIDE OF ETHYL UPON MORPHIA.

Morphia, in a state of fine powder, was introduced into a combustion-tube, strongly sealed at one end, a little iodide of ethyl added, and then absolute alcohol, in quantity judged to be sufficient to dissolve the alkaloid. I found about 25 grains might be conveniently employed in a tube of small bulk; and alcohol occupying about three times the space of the alkaloid was found sufficient, a very small quantity of iodide of ethyl being required. When the substances were all introduced, the tube was carefully sealed before the blow-pipe, and upon its cooling, the whole was immersed in boiling water. Complete solution took place when a small quantity of morphia was employed, but not so when more was used; action commenced very speedily, as was obvious from the nature of the solid product in the tube, which had not the appearance of morphia. The boiling was continued some hours when complete solution had not taken place at first, in order that any morphia which had at first remained undissolved might in its turn be acted upon, as the alcohol became free, as it were, by deposition of the new product. When the action had continued about six hours or so, the tube was allowed to cool, and then opened; the alcohol containing the excess of iodide of ethyl, nearly colourless and quite limpid, was poured off from the white crystalline solid product, which was then washed with a little

* Ann. Ch. Pharm. XXVI, 60.

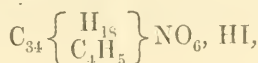
alcohol, and dried. It was found to dissolve readily in hot water; accordingly, the whole was treated in this manner, in case of any morphia remaining unattacked, from which, it being insoluble or very difficultly soluble in this menstruum, the product would by this means be purified. However, complete solution took place; and the fluid deposited, on cooling, a substance in fine white needles; these were collected, dried and analyzed, a preliminary experiment having shown that they contained much iodine.

In the following analysis, the iodine was determined by direct precipitation of an aqueous solution by nitrate of silver; the combustion made with chromate of lead:

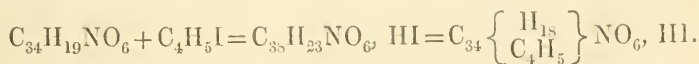
5.155	grs., dried at 212°, gave
9.725	„ carbonic acid, and
2.665	„ water.
4.470	„ gave
2.365	„ iodide of silver.

Experiment.		Calculated.			
Carbon . .	51.45	51.71	C ₃₈	228	
Hydrogen . .	5.74	5.44	H ₂₄	24	
Nitrogen . .		3.17	N	14	
Oxygen . .		10.87	O ₆	48	
Iodine . .	28.59	28.81	I	127.1	
		100.00		441.1	

A comparison of the experimental numbers with the calculation appended, will show that we have here a substance which may be termed the hydriodate of ethylmorphia, and whose constitution may be represented by the formula,



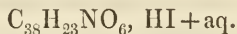
an atom of hydrogen of the original alkaloid being replaced by an atom of ethyl in the production of the new base, according to the equation,



The above salt is the only product of this decomposition, and the entire morphia is transformed into it: in the air-dry state, as crystallized from water, it contains an equivalent of water, which it loses at 212°.

$$\begin{cases} 9.805 \text{ grs. air-dry, lost in the water-bath} \\ 0.195 \text{ ,, water.} \end{cases}$$

The percentage calculated from this result is 1.98, and 1.98 is that corresponding with the formula :



Hydriodate of ethylomorphia is difficultly soluble in absolute alcohol, more easily so in rectified spirit: readily dissolved by hot water, from which it is deposited on cooling in brilliant colourless crystals, which magnifying power shows to be flattened prisms: it is not altered in the air.

Neither potash nor ammonia yielded a precipitate with an aqueous solution of this salt; but, before attempting to isolate the base which this fact pointed out would have to be sought in another way, I attempted to control the above formula by an analysis of a platinum-salt, but was unsuccessful. A saturated aqueous solution of hydriodate of ethylomorphia was converted into hydrochlorate by the successive employment of nitrate of silver and hydrochloric acid, and to the clear aqueous solution so obtained, bichloride of platinum was added; no precipitate was formed: a mixture of strong alcohol and ether was added to a small quantity of this solution, and it and the remaining aqueous fluid were allowed to stand during a night; in the morning the former fluid had deposited beautiful tufts of brilliant yellow needles which, though small, were seen when magnified to be well-defined groups of prismatic crystals, while at the bottom of the larger aqueous liquid was an amorphous yellow sediment; this was collected and burned in the usual way, but the resulting percentage of platinum was 2.5 too high to correspond with the theory. I look upon this as an effect of decomposition; and in this respect the new base seems to bear a close analogy with its parent alkaloid, which I have found very prone to change in contact with an excess of bichloride of platinum.

In order to obtain the base, a quantity of the crystallized hydriodate was dissolved in water gently heated, and oxide of silver gradually added till it was in excess. The fluid remained colourless so long as hydriodate was present, but instantly a decided excess of oxide of silver prevailed, dark streaks appeared, and upon filtration a highly caustic liquid was obtained, of a red-brown colour; this deposited no crystals upon cooling, or upon concentration, and when the whole was evaporated to complete dryness at 212° , a semi-transparent, solid, very dark-coloured residuc was obtained.

This residuc was found to be difficultly soluble in strong alcohol

(90 per cent), and a boiling solution deposited a substance amorphous to the naked eye, but revealing under the microscope distinct crystalline structure; it was scarcely altered in appearance by exposure to the air; but upon adding hydrochloric acid to a portion so exposed, it was observed to dissolve with slight but distinct effervescence to a yellow fluid, which gave a heavy yellow precipitate with chloride of platinum. It was readily and completely soluble in cold water to a red-brown fluid, which exhibited the following behaviour with various re-agents: with bichromate of potash a fine heavy yellow precipitate, soluble in hydrochloric acid; the acid solution became speedily green upon heating from reduction of the chromic acid;—with sulphate of copper a green, with acetate of lead a white, and in excess with nitrate of silver a black precipitate. The latter precipitate, upon the fluid in which it had been formed being heated, gave a slight metallic mirror, and was found to be not completely soluble in ammonia, showing that the base had been oxidized at the expense of the oxide of silver. When it was added to an aqueous solution of sesquichloride of iron, the latter assumed a green colour, darkening to an almost black fluid, with a larger quantity of the alkaline solution, and it was then found to give a blue precipitate with ferrideyanide of potassium, from which fact it is plain, that in this instance also the base had undergone oxidation: ammonia was evolved on heating solution of chloride of ammonium with the alkaline fluid.

Consideration of the foregoing reactions did not permit me to hope for a successful analysis of the alkaline residue, as the pure ethylomorpha; however I made the attempt:

$$\left\{ \begin{array}{l} 4.040 \text{ grs. dried at } 212^{\circ}, \text{ gave} \\ 10.130 \text{ ,, carbonic acid, and} \\ 2.505 \text{ ,, water.} \end{array} \right.$$

The percentages calculated from these numbers, I place in juxtaposition with the required values for the base:

Experiment.		Calculated for ethylomorpha.		
Carbon . .	68.38	72.84	C ₃₈	228
Hydrogen .	6.88	7.34	H ₂₃	23
Nitrogen .		4.47	N	14
Oxygen .		15.35	O ₆	48
		100.00		313

and the conclusion I draw from the comparison is, that the ethylomorpha I subjected to analysis had already undergone partial oxi-

dation from contact with oxide of silver. I cannot at present add anything to this imperfect history, for my material was exhausted in the experiments described, but sufficient is shown, I think, to make future inquiry of interest. It is obvious the base is extremely prone to decomposition by oxidizing agents; in this character it also resembles its parent morphia, but it shows the tendency in a more marked degree.

I did not attempt to continue the ethylation in this case, a trial of the kind being made with the methyl-product to be next described.

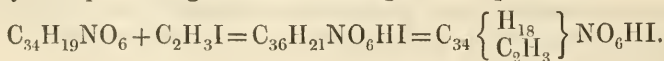
ACTION OF IODIDE OF METHYL UPON MORPHIA.

Morphia was submitted to the action of iodide of methyl under precisely the same circumstances as have been described with reference to iodide of ethyl; after about half an hour's boiling, the change appeared complete, a heavy white crystalline powder, occupying a larger space than the original alkaloid, being formed. The fluid remained almost colourless, and drained away readily from the new product when the tube was opened.

The product was found to dissolve readily in hot water, showing that complete change had taken place. As the water cooled, a deposit was quickly formed in fine brilliant, square, prismatic, colourless needles, of high refractive power. A portion was analyzed in the same manner as the former product:

		4.455 grs. dried at 212° gave { 8.245 „ carbonic acid, and 2.152 „ water. 4.335 „ give 2.380 „ iodide of silver.			
		Experiment.	Calculated.		
Carbon . .	50.47	50.57	C ₃₆	216	
Hydrogen . .	5.36	5.15	H ₂₂	22	
Nitrogen . .		3.27	N	14	
Oxygen . .		11.26	O ₆	48	
Iodine . .	29.66	29.75	I	127.1	
		100.00	427.1		

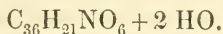
These results point to a decomposition precisely analogous, as was to be anticipated, to the one with iodide of ethyl; the hydriodate of methylmorphia being formed according to the equation



The salt in the crystallized state contains 2 equivs. of water which it loses at 212° .

9.630 grs. lost on drying in the water-bath
0.400 „ water.

The percentage calculated from this number is 4.15 ; and 4.04 is that which corresponds to the formula



This is precisely the formula found for the hydriodate of codeine as dried at 212° , by Professor Anderson;* so that the air-dry hydriodate of methylomorpha is identical in composition with the corresponding salt of codeine as dried at 212° ; the salts, however, are only isomeric, for nothing could be more unlike the fine crystalline alkaloid codeine, than the alkaline substance obtained by the action of oxide of silver upon the hydriodate of the new base. In short, it resembles in every particular the corresponding ethyl-compound in appearance and reactions so closely, that to describe them would be to repeat what has been said of that substance. I did not attempt an analysis of this base, but having obtained some in the dry state, proceeded to try the further action of iodide of methyl upon it.

With this view, the base was separated by the action of oxide of silver, of which an excess was attempted to be avoided, on the hydriodate, and subsequent evaporation of the caustic aqueous fluid, which was coloured reddish-yellow, to dryness at 212° ; in this state it presented an appearance as before said, exactly similar to that of ethylomorpha, produced by the same means, namely, that of a dark-brown, semi-transparent, amorphous mass. Its reactions were identically those of the former base. The methylomorpha so obtained had most probably commenced to undergo partial oxidation, but as this was unavoidable, the whole was powdered and placed in contact with iodide of methyl and alcohol. Action commenced even in the cold; for on shaking together the contents of the vessel, the fluid became filled with a light-brown flocky substance, which upon trial gave a precipitate with nitrate of silver, showing the presence of hydriodic acid. To ensure reaction, the tube containing the mixture was sealed, and subsequently placed in water at 212° ; upon this a resinous substance was immediately formed at the bottom of the tube, and the supernatant liquid became quite clear, the flocky matter disappearing. The heating was continued about half an hour, and no further change taking place in appearance, the tube was allowed

* Trans. Roy. Soc. Edinb. XX.

to cool; a very slight deposit appeared adhering to the sides of the tube, of rather a resinous nature. The tube was opened, and the clear fluid poured from the resin; water was added to it, no change produced; the aqueous fluid was then distilled, to separate the excess of iodide of methyl, and subsequently evaporated at 212° ; the residue left was a black amorphous mass, which was found to dissolve only partially in water to a very dark fluid, while a considerable portion remained in the form of a black powder; this proved to be insoluble in every menstruum, with the exception of strong nitric acid, which gave a reddish-yellow solution, nitrous acid being evolved. The watery fluid contained a hydriodate of a base; the quantity being very small, I attempted to obtain some idea of the change effected by converting it into a platinum-salt, carefully avoiding an excess of platinum-solution. I obtained a yellow curdy salt, but in very small quantity, and on determining the percentage of platinum with the utmost care I obtained 21.14 per cent, which is far above that required by the platinum salt of even morphia itself.

The resinous deposit which was described as adhering to the sides of the tube, appears to be identical with the substance contained in the alcoholic fluid; at least it furnished a solution in hot water, which upon evaporation at 212° , left a residue agreeing in its characters and qualitative reactions precisely with that left by drying up the spirituous liquid; its quantity was too small to admit of quantitative experiments.

I do not venture to draw any definite conclusions from these facts with regard to the continued action of iodide of methyl upon methylo-morphia, but that a decomposition of a more complicated nature than the simple assumption of another equivalent of ethyl takes place is, I think, obvious. It will be shown presently that this conclusion seems to be warranted by a deportment of a similar nature observed in reference to a basic product derived from codeine. Further experiment, however, must decide the nature of these changes.

REACTION BETWEEN MORPHIA AND CHLORIDE OF AMYL.

Morphia was placed in contact with chloride of amyl under circumstances precisely similar to those which have been mentioned with regard to iodide of ethyl and methyl. No change took place after three days; for upon opening the tube, the alkaloid was found unaltered. Knowing the reactions of this member of the alcohol series to be somewhat sluggish, I repeated the experiment, expecting a longer exposure to heat might be requisite to effect a decomposition.

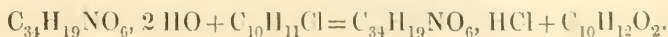
Accordingly, a tube was sealed as before, and the contents were kept boiling constantly for about fourteen days. In about four or five days, a crystalline substance began to be formed, and upon opening the tube at the fortnight's end, the solid deposit which had gradually collected, was found to be a hydrochlorate; the alcoholic fluid was poured away and the salt washed and dried; it was soluble in hot water, and the colourless solution gave, upon gentle evaporation, a crystalline substance, in the form of opaque tufts of four-sided prisms (magnified); when dried and subjected to analysis, the crystals gave these results :

- I. { 3.060 grs. dried at 212° , gave
 { 1.340 „ chloride of silver.
 II. { 4.290 „ dried at 212° , gave
 { 1.895 „ chloride of silver.

Experiment.		Calculated.		
Carbon . .		63.45	C_{34}	204
Hydrogen .		6.22	H_{20}	20
Nitrogen . .		4.35	N^2	14
Oxygen . .		14.94	O_6	48
Chlorine . .	10.83 10.92	11.04	Cl	35.5
		100.00		321.5

which, upon a comparison with the calculation, and the formula adjoined, which is that of morphia, will show that we have not in this case a decomposition analogous with the preceding ones; the hydrochlorate here formed is indeed the salt of morphia; its appearance and characters are identical with the latter; and the addition of ammonia to its aqueous solution, yields a crystalline precipitate, which has all the properties of pure morphia, as ascertained by various tests.

The reaction thus occurring may be explained as taking place between the chloride of amyl and the elements of water, of which morphia, as crystallized from alcohol (the state in which it was employed) retains 2 equivs. when dried in the air; indeed, they are not completely expelled, except at a temperature considerably above 212° F. So far as I remember, I used absolute alcohol; and the chloride of amyl had been, I was told, distilled from lime: at all events, when tested with nitrate of silver, it gave only slight indications of chlorine in a state precipitable by this reagent; the equation representing this change then appears to be :



I am not aware if the chloride of amyl has been found to undergo this transformation simply in presence of water; possibly it may, under the circumstances of my experiment; if not, the action of the morphia in this respect seems to be analogous to that of potassa, &c., in producing the alcohols from their corresponding halogen compounds.

I propose subjecting artificially dried morphia to the action of anhydrous chloride of amyl, to ascertain if the compound of this series, corresponding to the ethyl and methyl products, cannot be so obtained.

I now proceed to give the result of some experiments upon a vegetable alkaloid, closely allied in origin with the former, viz.: codeine.

ACTION OF IODIDE OF ETHYL UPON CODEINE.

About 25 grains of finely-powdered codeine were placed in a combustion-tube, about 2 feet long, sealed at one end; iodide of ethyl was poured upon it in small quantity, and absolute alcohol added in such proportion as was judged sufficient to dissolve the alkaloid; the tube was sealed. On cooling of the tube, its contents were shaken together, and a perfectly clear homogeneous fluid was obtained: the whole was placed in boiling water. In about two hours, the contents of the vessel became nearly solid, from the presence of a white, crystalline substance. This was considered to indicate the completion of the action.

Upon the appearance of the crystalline product, the tube was allowed to cool. When it was cut open, the fluid was suffered to drain off from the solid, which was then scraped out, placed upon a filter, washed with a little alcohol, and finally dried between folds of paper. The substance then presented the appearance of a highly crystalline, white mass; it was found to dissolve completely, on being covered with a small quantity of cold water. On filtering the fluid from a little dust, a tendency to crystallization was observed: this was overcome by the addition of some drops of warm water, and the clear liquid was placed in the vacuum of an air-pump, and left for a night. In the morning, although the apparent decrease in the bulk of liquid was but small, a considerable crystalline deposit was formed, which, under magnifying power, was seen to be made up of tufts of fine, silky, white needles; it was freed from the mother-liquor, and then collected and dried. An experiment on the small scale showed that the substance contained much iodine; accordingly

it was submitted to analysis. The iodine in the following analysis was determined by direct precipitation of an aqueous solution by nitrate of silver; the combustion made, of course, with chromate of lead:

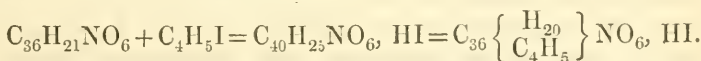
5.025	grs. dried at 212°, gave
9.690	„ carbonic acid, and
2.658	„ water.
4.453	„ gave
2.300	„ iodide of silver.

Experiment.		Calculated.	
Carbon . .	52.59	52.73	C ₄₀ 240
Hydrogen .	5.87	5.71	H ₂₆ 26
Nitrogen .		3.07	N 14
Oxygen .		10.57	O ₆ 48
Iodine . .	27.91	27.92	J 127.1
		100.00	455.1

These results clearly show that we have here a substance whose rational formula, as an hydriodate of a new base, may be represented thus:



derived from codeine, according to the following equation, by the substitution of an atom of ethyl for an atom of hydrogen; it may be called hydriodate of ethylcodeine:



I immediately attempted to obtain the base by decomposition of the salt by ammonia and potash, but no precipitate was obtained even in very concentrated solutions, or on the addition of alcohol and ether. However, when the potass-fluid was boiled, it became muddy, and on cooling, an oily substance was deposited, which presented an appearance somewhat similar to codeine; but upon dissolving it in boiling water, it failed to take the crystalline character of this alkaloid under similar circumstances, for the water gave no deposit at all on cooling, and it was only by evaporation that the same oily matter again made its appearance. I am inclined to think this not the ethylcodeine, but a product of decomposition. I next attempted to isolate the base by acting on the hydriodate with oxide of silver, which was added in successive small quantities to a warm aqueous solution of the salt till it was obviously in excess; a highly alkaline

fluid was obtained, of which a small portion was evaporated to dryness at 212° ; a semi-transparent, dark-coloured residue remained, which effervesced with hydrochloric acid, and dissolved to a yellow fluid, which gave, with bichloride of platinum, a yellow precipitate, at first amorphous, but becoming highly crystalline on standing; this character, as will be seen presently, belongs to the platinum-salt of ethylcodeine obtained by double decomposition, and I conclude that the new basic substance is uncrystalline, highly soluble in water, and capable of absorbing carbonic acid from the air. The nature of my materials compelled me to extreme economy, and I contented myself with this single attempt at obtaining the base itself in a dry state; its characters not being inviting for analysis any more than those of the corresponding morphia-compound, I preserved the residue of that which I had prepared, for an experiment to be described hereafter, controlling the former analysis of the hydriodate by a platinum determination in the double salt of the ethylcodeine and chloride of platinum.

The mother-liquor which had deposited the hydriodate submitted to analysis, was allowed to stand in the air; it became, after some time, again nearly filled with tufts of delicate needles, which gradually assumed a new crystalline form, the whole being transformed into well-defined, brilliant rhombic crystals of high refractive power. A portion of these was dissolved in water, and solution of nitrate of silver added; from the fluid filtered from the iodide of silver hydrochloric acid separated the excess of silver, and to the liquid again filtered was added bichloride of platinum; an amorphous precipitate immediately appeared of a pale yellow colour, but it speedily became crystalline, and on allowing the fluids to remain at rest, a salt was obtained in very fine, and well-defined, though small, rhombic crystals of a rich yellow colour; of this salt,

$$\begin{cases} 5.910 \text{ grs. gave} \\ 1.060 \text{ ,, platinum.} \end{cases}$$

The percentage calculated from this result is 17.93, which falls somewhat below that required by the formula of an anhydrous salt of ethylcodeine, which is 18.51; but as the salt was so finely crystallized, and I could perceive no obvious source of error, I am inclined to think that this base, like its parent codeine, retains an equivalent of water in this form of combination. The percentage of platinum corresponding to the formula,



is here contrasted with the result of experiment,

Theory.

Experiment.

18.20

17.93

and is, I think, sufficient to prove, together with the foregoing analysis, the true composition of the base in question. When this salt is boiled in water it becomes at first resinous, then dissolves; it appears to have suffered decomposition, a substance being deposited, on cooling of the fluid, in rounded transparent granules, rather than oblique rhombic crystals.

ACTION OF IODIDE OF ETHYL ON ETHYLOCODEINE.

I mentioned that I attempted to isolate ethylocodeine by decomposition of its hydriodate by oxide of silver. A caustic fluid was obtained which, upon evaporation *in vacuo*, left an amorphous semi-transparent residue. I concluded from the experiment then mentioned with regard to a platinum-salt obtained from a similar trial on the small scale, in which the caustic fluid was evaporated to dryness at 212° , that the base so obtained was the true ethylocodeine.* It was now my object to try, by the further action of iodide of ethyl, whether the ethylation was complete, or if another atom of hydrogen could be taken away and replaced by ethyl. With this view, the residue obtained by evaporation of the alkaline fluid *in vacuo* was dissolved in absolute alcohol, iodide of ethyl added, and the whole sealed up in a tube, which was exposed to the temperature of boiling water; no crystalline deposit appearing, the action was continued for about twenty-four hours; at the end of this time the fluid became rather dark coloured, and a resinous black-looking deposit was formed. The tube was opened, the fluid poured from the deposit into a small flask, and the chief part of the iodide of ethyl distilled off; water was added to the remaining fluid, which was then placed on the water-bath and allowed to remain some hours; at the end of this time all smell of iodide of ethyl ceased, and a black substance deposited in small quantity: the fluid was filtered from this, and upon the addition of nitrate of silver, a considerable precipitate of iodide was formed; the excess of silver was removed by hydrochloric acid, and bichloride of platinum was added to the filtered fluid; an amorphous yellow precipitate was formed which, upon standing, became partially converted into a substance which, under the microscope, appeared not crystalline, but had the form of rounded grains; this was collected and analyzed. The resulting percentage of platinum obtained was 21.20, which is considerably above that of

* Possibly it had undergone slight oxidation

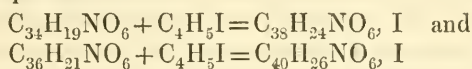
codeine itself. This, and the appearance of the resinous substance—which I may mention dissolves almost completely in boiling hydrochloric acid, and is again thrown down by potash—seem to point to decomposition of quite another character than the one sought. I am unable at present to elucidate this question, but it seems worthy of investigation. It is perhaps proper to state here, that in the first experiment I made upon the action of iodide of ethyl upon codeine, the action was continued some hours after the first deposit had been observed, and that in this case also a resinous deposit was formed, the fluid was highly coloured, and the crystalline product was not nearly so well-defined in its characters. It was for this reason that the action in the experiment, the product of which gave the results stated, was stopped as soon as the large quantity of crystalline deposit appeared.

I have satisfied myself that codeine is rapidly acted upon by iodide of methyl; no doubt the resulting decomposition is similar in nature to that effected by iodide of ethyl.

The preceding experiments are not complete enough, or in some respects sufficiently decided in their results, to permit of any very definite conclusions being drawn as to the exact nature of the alkaloids to which they relate; so much, however, has been shown, I think, as to call for some attempt at deduction.

The nature of the alkaline substances produced by the action of oxide of silver upon what I have termed the hydriodates of ethylo- and methylo-morphia and codeine, would seem to ally them more closely to what Hofmann has called oxides of tetra-bases than to any other bodies. In the slight but distinct tendency they exhibit to absorb carbonic acid, they are certainly removed from any close analogy with the alkaloids from which they are derived; although, in the single analysis I have given of one of these substances, the so-called ethylo-morphia, the evident oxidation it had undergone prevents any support being afforded to this assumption on the one hand, so likewise on the other it does deprive it of any pretensions to correctness. The only conclusion I can venture to draw from the facts obtained, as to the continued action of the iodides of methyl and ethyl upon these substances, is that some change is effected which causes the formation of a basic body, having a lower atomic weight than the original compound, and the production of the resinous matters seems also to point to a breaking up of the primary molecule; but of course the experiments from which this is inferred are too incomplete to warrant any more decided opinion as to the precise

nature of the decomposition. It would follow necessarily, from the foregoing view of the constitution of the ethyl and methyl new basic compounds isolated from their salts, that if the alkaloids from which they are derived were placed in their appropriate class, according to the provisional nomenclature of Hofmann, they would come under the designation of nitrile bases; and in the decompositions in which morphia and codeine have been seen to be transformed, they would have had attached to them the elements of iodide of ethyl, for instance, as expressed thus:



the new salts becoming rather analogous to iodide of ammonium than to hydriodates of natural alkaloids.

Experiments made in the same direction, with others of the vegetable bases, would doubtless prove of considerable interest; since, notwithstanding both those to which I have given my attention appear to belong to the same class, as was perhaps to be expected from their being so closely allied in origin, it is extremely probable that alkaloids, contained in plants of a different natural family, will be found to possess different constitutions; I hope to examine a few.

I would venture to make one other remark before concluding this paper. The fact, that by the action of iodide of methyl upon morphia, a salt is produced, only isomeric and in no way identical with hydriodate of codeine, the base of the new salt differing so widely in character from the latter alkaloid, does not appear to me to afford great stimulus to any hopes of forming the natural alkaloids by this means; since, if we fail in the case of two natural products of the very same plant, it seems far less probable to bring about such a result as the production of a base identical with a natural formation, from a substance with which it has no relation, beyond a certain difference in their relative proportions of carbon and hydrogen.

In conclusion, I append a list of the salts I have examined, considered as iodides, in their dry and crystallized states:

Iodide of methylmorphia, dried at 212^0	$\text{C}_{36}\text{H}_{22}\text{NO}_6, \text{I}$
" " " crystallized	$\text{C}_{36}\text{H}_{22}\text{NO}_6, \text{I} + 2 \text{H}_2\text{O}$
" " ethylmorphia, dried at 212^0	$\text{C}_{38}\text{H}_{24}\text{NO}_6, \text{I}$
" " " crystallized	$\text{C}_{38}\text{H}_{24}\text{NO}_6, \text{I} + \text{H}_2\text{O}$
" " ethylocodeine is anhydrous	$\text{C}_{40}\text{H}_{26}\text{NO}_6, \text{I}$
Platinum-salt of " dried at 212^0	$\text{C}_{40}\text{H}_{26}\text{NO}_6, \text{Cl}, \text{PtCl}_2 + \text{H}_2\text{O}.$

XVI.—*Note on Sulphantimoniate of Copper and Zinc.*

BY PROFESSOR ETTLING.

(FROM A LETTER TO DR. HOFMANN.)

In the January Number of the Quarterly Journal of Chemistry for 1852, p. 332, Mr. Field communicated the analysis of a new mineral which, according to the statements of Mr. Domeyko, occurs in large quantity in the Pit Altar, near Coquimbo, together with zinc-blende, iron-pyrites, and fahl-ore, and differs from the latter, especially from the zinc-fahl-ore, which is closely allied to it, by its greenish-grey colour, by giving a much lighter red streak, and by its softness.

On recalculating the results obtained by Mr. Field, who has omitted to translate his data into a formula, I find that antimony and arsenic in this ore are not present in the form of tersulphides, as in fahl-ore, but in the form of pentasulphides, as in Enargite and Xanthocon, a fact which may serve to explain the difference between the properties of this ore and zinc-fahl-ore.

Mr. Field's analysis led to the following results :

Sb.	As.	S.	Cu	Zn.	Fe	Ag.	Total.
20·28	3·91	30·35	36·72	7·26	1·23	0·07	99·82

If the amount of sulphur be calculated, which is required to convert copper, zinc, iron, and silver into sulphides, we find 13·525 per cent, leaving 16·825 per cent for the antimony and arsenic. Calculated as tersulphides, these two metals would require 10·048 per cent of sulphur, leaving an excess of 6·77 per cent. Calculated on the other hand as pentasulphides, antimony, and arsenic require 16·753 per cent leaving only the slight excess of 0·072 per cent. Hence it cannot be doubted that the new mineral is actually a *sulphantimoniate and sulpharseniate of copper and zinc*.

Since the sulphur of the basic sulphides stands to that of the acid sulphides = 13·525 : 16·753 = 4 : 5, the formula of the mineral may be written $4(\text{Cu}_2\text{S}, \text{ZnS}, \text{FeS}, \text{AgS}) + \text{SbS}_5, \text{AsS}_5$ or approximately $2(4\text{Cu}_2\text{S}, \text{SbS}_5) + 4(\text{ZnS}, \text{FeS}, \text{AgS}) + (\text{SbS}_5, \text{AsS}_5)$.

Enargite, as is well known, is $3\text{Cu}_2\text{S}, \text{AsS}_5$, and occurs at Morococha in Peru.

PROCEEDINGS
AT THE
MEETINGS OF THE CHEMICAL SOCIETY.

ANNIVERSARY MEETING,

March 30, 1853.

PROFESSOR DAUBENY, President, in the Chair.

The Report of the Council, and the audited Account of the Treasurer, were read (vid. p. 147).

The following gentlemen were duly elected as Council and Officers for the ensuing year :

PRESIDENT.

Colonel Philip Yorke, F.R.S.

VICE-PRESIDENTS, WHO HAVE FILLED THE OFFICE OF PRESIDENT.

W. T. Brande, M.D.

Charles G. B. Daubeny, M.D., F.R.S.

Thomas Graham, F.R.S.

VICE-PRESIDENTS.

H. Bence Jones, M.D., F.R.S.

Lyon Playfair, C.B., Ph.D., F.R.S.

G. D. Longstaff, M.D.

Robert Warington, Esq.

SECRETARIES.

Benjamin Collins Brodie, F.R.S.

Theophilus Redwood, Ph.D.

FOREIGN SECRETARY.

A. W. Hofmann, Ph.D., F.R.S.

TREASURER.

Robert Porrett, F.R.S.

OTHER MEMBERS OF THE COUNCIL.

Thomas Anderson, M.D., F.R.S.	Dr. Miller.
John Blyth, M.D.	Capt. J. W. Reynolds.
Dugald Campbell, Esq.	Thomas Taylor, Esq.
Warren de la Rue, Ph.D., F.R.S.	J. Arthur Phillips, Esq.
J. H. Gladstone, Ph.D.	George Wilson, M.D., F.R.S.
William Herapath, Esq.	A. W. Williamson, Ph.D.

The thanks of the Society were voted to the President, Vice-President, and Council, for their services during the past year.

April 4, 1853.

COLONEL PHILIP YORKE, President, in the Chair.

The following donations were announced :

“Report on the Bad Quality of Chemical Products and Drugs used by Calico Printers,” by F. Craze Calvert: from the Author.

“The Journal of the Society of Arts for March:” from the Society.

“The Literary Gazette for March 19th:” from the Publishers.

“The Pharmaceutical Journal for April:” from the Editor.

A paper was read :

“On some Compounds of Urea, and on a New Method for the Determination of Chloride of Sodium and of Urea in Urine,” by Baron Liebig.

April 18, 1853.

COLONEL PHILIP YORKE, President, in the Chair.

Stevenson Macadam, Esq., of Edinburgh, was admitted a Fellow of the Society.

The following donations were announced :

“The Journal of the Society of Arts for April the 8th and 15th:” from the Society.

“The Literary Gazette for April 9th and 16th:” from the Publishers.

"The Journal of the Franklin Institute for February and March, 1853:" from the Institute.

John A. Mease, Esq., of the Lake Chemical Works, South Shields, was elected a Fellow of the Society.

The following papers were read :

"On the general distribution of iodine and bromine:" by Stevenson Macadam.

"On the solid compound obtained by distilling stearic acid with lime:" by Thos. H. Rowney Ph.D.

May 2, 1853.

COLONEL PHILIP YORKE, President, in the Chair.

The following donations were announced :

"The Literary Gazette," 3 Numbers: from the Publishers.

"The Journal of the Society of Arts," 2 Numbers: from the Society.

"The Pharmaceutical Journal," for May: from the Editor.

Becquerel, M., "*Traité Experimental de l'Electricité et du Magnétisme et de leurs Rapports avec les Phénomènes naturels*," Tomes VII, 8vo, Paris, 1834-40.

Bergman, "Physical and Chemical Essays," by Edmund Cullen, M.D., 8vo, London, Vol. III, 1788-91.

Berzelius, J. J., "*Traité de Chimie*," traduit par A. J. L. Jourdan, Tomes VIII, 8vo, 1829-33.

Chaptal, M. J. A., "*Elements of Chemistry*," translated from the French, Vol. III, 8vo., London, 1800.

Cramer, John Andrew, M.D., "*Elements of the Art of Assaying Metals*," in 2 Parts, 8vo., London, 1741.

Fritschius, John Christian, "*The Principles of Pyrotechnical Metallurgy and Metallick Assaying*," 12mo.

Gellert, C. C., "*Metallurgic Chemistry*," 8vo., London, 1776.

Girtanner, Christoph, "*Anfangsgründe der Antiphlogistischen Chemie*," 8vo., Berlin, 1795.

Glauber, John Rudolph, "A description of New Philosophical Furnaces, or a New Art of Distilling, also a description of the Tincture of Gold, or the true Aurum Potabile," 12mo., London, 1651.

Greu, Dr. Friedrich Albrecht Carl, "Grundriss der Chemie," Erster Theil, 8vo., Halle, 1796.

———, "Systematisches Handbuch der gesammten Chemie," 8vo., Band II, Erster Theil, 1795.

"Pyritologia, or a History of the Pyrites," translated from the German, by J. H. Henckel, 1757, 8vo., London.

Henry, Wm., M.D., F.R.S., "Elements of Experimental Chemistry," Vol. II, 8vo., London, 1826.

Klaproth, Martin Henry, "Analytical Essays towards the Promoting the Knowledge of Mineral Substances," 8vo. London, 1801.

Lagrange, J. B. Bouillon, "Manual of a Course of Chemistry," Vol. II, 8vo., London, 1800.

"Metals, Mines, and Minerals—A Collection of scarce and valuable Treatises upon." In four Parts, 12mo., London, 1738.

Webster, John, "Metallographa; or, an History of Metals," 8vo., London, 1671.

Packe, Chr., "153 Chemical Aphorisms," 32mo., London, 1688.

Sandivogius, Michael, "A New Light of Alchemy taken out of the Fountain of Nature and Manual of Experience," to which is added "A Treatise on Sulphur," "Nine Books on the Nature of Things," also, "A Chemical Dictionary, explaining hard places and words met withal in the writings of Paracelsus, and other obscure authors."

Valentine, Basil, "Chariot of Antimony," with Annotations of Theodore Kirkringius, M.D., 12mo., London, 1678.

From Henry James Brooke, Esq., of Clapham Rise.

A communication was made :

"On Deposits of Soluble or Gelatinous Silica in the Lower Beds of the Chalk Formation:," by John Thomas Way.

May 16, 1853.

PROFESSOR GRAHAM, Vice-President, in the Chair.

The following donations were announced :

"The Quarterly Journal of the Geological Society:" from the Geological Society.

"The Literary Gazette," 3 numbers: from the Publishers.

"The Journal of the Society of Arts," 2 numbers: from the Society of Arts.

The following papers were read :

1. "On a Compound Sulphate of Potash and Soda:" by J. H. Gladstone, Ph.D.

2. "Note on Thierschite:" by J. Liebig.

3. "On Kyanurenic Acid:" by J. Liebig.

June 6, 1853.

PROFESSOR GRAHAM, Vice-President, in the Chair.

The following donations were announced :

"Bulletin de la Classe Physico-mathématique de l'Académie Impériale des Sciences de St. Petersburg," Tom. IX and X: from the Academy.

"The American Journal of Science and Arts," for May, 1853: from the Editors.

"On the Relations between the Atomic Weights of Analogous Elements:" by G. H. Gladstone, Ph.D.: from the Author.

"Literary Gazette," 3 numbers: from the Publishers.

The following papers were read :

1. "Analysis of the Waters from the Deep Well of the Westbourne Water-works at Westbourne Grove, of the Well in Russell Square, and the Artesian Well at the Hanwell Asylum:" by Charles Harwood Clarke, M.A., F.S.A., and Henry Medlock, F.C.S.

2. "On the Increase in Weight of Molasses Casks, occasionally arising from Absorption:" by William Ferguson.

3. "On some New Basic Products obtained by the decomposition of Vegetable Alkaloids:" by Henry How.

June 20, 1853.

COLONEL PHILIP YORKE, President, in the Chair.

Andrew Tomlin, Esq., of Valparaiso, was elected a Fellow of this Society.

The following communications were made:

1. "On the Conditioning of Silk:" by P. J. Chabot, M.A.
 2. "On a New Method of Estimating the Strength of Chloride of Lime:" by Dr. Astley P. Price.
 3. "On a Gas-furnace for Organic Analysis:" by Dr. Hofmann.
-

ANNUAL GENERAL MEETING,

MARCH 30, 1853.

REPORT OF THE COUNCIL.

The Council in presenting the following returns from the Secretaries and Treasurer, are again able to announce that the state of the Chemical Society continues satisfactory, both as to its present condition and future prospects.

STATEMENT OF THE NUMBER OF FELLOWS OF THE CHEMICAL SOCIETY AT THE PRESENT TIME, AND AT THE CORRESPONDING PERIOD OF LAST YEAR.

Present number of Fellows	241
Deaths, resignations, &c., since last Anniversary Meeting	20
Elected since last Anniversary Meeting	16
Decrease since last Anniversary Meeting	4
Number of Fellows at period of last Anniversary Meeting . .	245

In reference to the small diminution in the number of Fellows, it is right to mention that the names of thirteen Fellows, who had for some time ceased to pay their subscriptions, have, since the last Report, been removed by the Society from the list, in compliance with Bye-law IV.

FELLOWS DECEASED.

John Sylvester, Esq., 96, Great Russell Street.

Thomas Thomson, M.D., F.R.S. L. and E., F.G.S., &c.,
Glasgow.

AUDITED REPORT OF THE TREASURER.

ROBERT PORRETT (TREASURER) IN ACCOUNT WITH THE CHEMICAL SOCIETY.

Dr.

Cr.

1852. March 30.	To Balance from last Account	£.	s.	d.	1853. March 26.	By payment to Directors of Polytechnic Institution, for One Year's Rent of Rooms to 25th inst.	£.	s.	d.
1853. March 26.	" Subscriptions (£327) and Compositions (£60) since received	91	12	2	" "	" Ditto to Henry Watts, for One Year's Salary as Editor of the Society's Journal	120	0	0
" "	" Admission Fees from 22 new Members	387	0	0	" "	" Ditto to H. Baillière, for Publishing the So- ciety's Journal	50	0	0
" "	" One Year's Dividend on £300, 3 $\frac{1}{4}$ Consols, minus Property Tax	44	0	0	" "	" Ditto to John Kirkman, for Attendance and for Tea, Coffee, &c.	103	2	6
" "	" One Year's Rent in advance, to January, 1854, from the Meteorological Society, for use of Rooms	8	14	10	" "	" Ditto to J. Bonomi, for Model of Common Seal	40	6	4 $\frac{1}{2}$
" "	" Proceeds of Sale of "Memoirs"	20	0	0	" "	" Ditto to G. Barclay, for Common Seal and Press	5	0	0
		3	12	4	" "	" Ditto to C. Whiting, for Printing	29	0	0
					" "	" Ditto for Books, Stationery, Postage-stamps, &c. .	11	10	6
					" "	" Ditto to the Collector, for his Poundage . . .	24	8	3
					" "	" Ditto to Imperial Gas-Light Company . . .	15	19	0
					" "	" Ditto for Ironmongery and Gas-Fittings . . .	1	13	3
					" "	" Ditto to Robert Ireland, for Book-cases . . .	6	2	5
					" "	" Ditto for Chemicals	11	18	0
					" "	" Ditto to Hannell & Ellis, for a Glass-case . .	2	14	0
					" "	" Ditto to J. Giller, for Plate-glass to a Case .	9	0	0
					" "	" Ditto to National Linen Company, for Damask	0	12	0
					" "	" Balance carried to next Account	0	14	6
					" "		122	18	6 $\frac{1}{2}$
		£ 554	19	4		London, March 26, 1853,	£ 554	19	4
						R. PORRETT, Treasurer.			
						Examined and found correct,			
						(Signed) { ALFRED SMEE, JOHN J. GRIFFIN, } Auditors. CHARLES HEISCH, }			

LIST OF PAPERS READ AT THE CHEMICAL SOCIETY SINCE THE LAST ANNIVERSARY MEETING.

"On the detection and qualitative separation of Tin, Antimony, and Arsenic; and on the relation existing between these metals and others which are precipitated from their acid solutions by Sulphuretted Hydrogen." By Charles L. Bloxam.

"Researches on the Constitution of Organic Acids." By M. Charles Gerhardt.

"Note on the preparation of Carbonate of Amyl." By John A. Bruce.

"New formation of Salicylic Acid." By Dr. Gerland.

"On the preparation of Anhydrous Acetic Acid." By M. Charles Gerhardt.

"Chemical Memoranda." By Robert Warington.

"On the action of Ammonia upon Binoxysulphocarbonate of Amyl." By Matthew W. Johnson.

"On a New Process for the detection of Fluorine when accompanied with Silica." By George Wilson, M.D.

"On a New Test for Strychnia." By Mr. J. H. Pepper.

"A Note on the existence of Strontia in the Well-waters of Bristol." By Messrs. William and Thornton J. Herapath.

"On a new method for the Analysis of Chrome Ores, and on Commercial Chlorochromate of Soda." By F. Crace Calvert.

"On certain Isomeric Transformations of Fats." By Patrick Duffy.

"On the qualitative separation of Arsenic, Tin, and Antimony." By Geo. F. Ansell.

"Observations upon a new series of Double Chlorides containing Diplatossammonium." By G. B. Buckton.

"On the action of Iodine on Phosphorus." By B. C. Brodie.

"On the Acid Oxalates of the Earths." By Edward Clapton.

"Researches on the Anhydrous Organic Acids." By Charles Gerhardt.

"On the valuation of Indigo." By Dr. Frederick Penny.

"Note on the Presence of Alumina in the Urine." By Lionel S. Beale.

"On the reaction of Glycocoll with Potash." By Professor Horsford.

"On the constitution of Stearinc." By Patrick Duffy.

"On the Compounds of several essential Oils with the Alkaline Bisulphites. By C. Bertagnini.

"On some New Compounds of Tellur-ethyl." By Professor Wöhler.

"Analytical Notes." By A. B. Northcote and A. H. Church.

"On the Law of Electrolysis." By Professor H. Buff.

"On the mode of estimating the value of Red Prussiate of Potass, and of testing the strength of Bleaching Liquors." By Francis Lieshing.

ANNIVERSARY ADDRESS OF THE PRESIDENT.

CHARLES DAUBENY, M.D., F.R.S., &c.

GENTLEMEN,

At our last Anniversary Meeting, I took occasion to descant upon the advantages that might accrue to science from the juxtaposition of the different chartered Societies devoted to this object, in some convenient and central locality.

You may recollect my having then stated, "that I for one should heartily hail the day, which might witness the assemblage of all the principal Bodies dedicated in this place to the study of Nature under one and the same roof, pursuing their separate labours indeed independently, but at the same time deriving mutual support and assistance from their contiguity; exercising over each other no paramount jurisdiction, but moving onwards in harmony and concert, as became the federal members of the great Republic of Science."

My opinions with regard to the desirableness of such an arrangement have since that period by no means undergone a change; nor am I aware that, in expressing the above sentiments on the occasion referred to, I said anything in which the great body of the Society over which I presided would not, at the time, have heartily concurred. Nevertheless, since we last met, circumstances have transpired with respect to the views of Government, in relation to the mode of carrying out the object alluded to, to which I confess myself as little able to assent, as any other of our Members can be.

It appeared from certain remarks which fell from the late

Chancellor of the Exchequer, in a speech delivered by him in the course of the preceding session, that it was then in the contemplation of Government to purchase a piece of land at Kensington Gore, partly under the expectation, that the chartered Scientific Societies of the Metropolis would accept as a boon the offer of any suitable suite of apartments which might be there erected at the public expense, as being a mode of realising a project, in which, it was presumed, that they all entertained a common interest.

Now, as a general repugnance was felt throughout the Societies referred to, to a removal to so distant a locality, it seemed necessary, that whilst we expressed, as in duty bound, our acknowledgments for the liberal disposition towards Science evinced by her Majesty's Government, we should at the same time, one and all, in order to prevent misapprehension, intimate our dissent to the particular scheme, by which our interests were thought to be consulted. And with regard to this Society in particular, I am persuaded, that the difficulty which most of our Members would find in resorting to so remote a part of the suburbs, for the purpose of attending our Meetings, would greatly counterbalance any advantage that might accrue from the gratuitous supply of apartments, even if by so doing we could hope to bring about that general juxta-position of scientific bodies, which we are all agreed to consider as desirable.

But it could not be forgotten, that three at least of the Societies included in this proposed arrangement are already provided with gratuitous accommodations in a central part of London, and are therefore less likely, even than ourselves, to consent to a removal to a more distant locality.

Without, therefore, presuming to anticipate what may be deemed convenient or advantageous hereafter, when perhaps the tide of population may roll westward, and the facilities of communication between distant parts of the metropolis may be increased, the Council deemed that they were not stepping beyond their proper functions, in protesting at the present time against the contemplated removal; and with this intent, directed me, as their President, to state to the Royal Society, in reply to a minute of the Council of that Body, having reference to this proposition, "that whilst they are ready to aid in promoting a practicable scheme, for the juxta-position of the said Scientific Societies, they are decidedly of opinion, that a removal of their library and place of meeting to Kensington would be seriously detrimental to the interests of the Chemical Society."

It will give me sincere pleasure to find, either that this or some future Government may be sufficiently alive to the importance of

Physical Science, and sensible of the disadvantages under which it struggles in this country through the dispersed state of the Societies formed for its cultivation, to provide us all with some central and convenient establishment, where we can pursue our labours in common; but until this day arrives, let us be encouraged by recollecting what our predecessors in the same field have accomplished without such extraneous aid, and what it may be possible, therefore, for us also to achieve by our own unassisted efforts.

Of this, indeed, the illustrious chemist who has been lost to us since our last Anniversary—I mean Dr. Thomas Thomson of Glasgow—affords us, as I conceive, one of the most instructive examples.

In early youth, not only without any of those appliances which some chemists, at least in foreign lands, have derived from their respective governments, but even without any further scientific training than what he could obtain from the public courses of lectures delivered at Edinburgh; in spite, too, of restricted means, and the absence of private patronage, he gradually raised for himself a reputation for extensive knowledge, which placed him in the first rank amongst the cultivators of his own particular Science. Indeed if amongst the chemists of the last generation, Dr. Dalton stood pre-eminent for the comprehensiveness of his generalisations, and Sir Humphry Davy for the brilliancy of his discoveries, Dr. Thomson may be regarded as holding the foremost place for his acquaintance with the facts of the Science, his careful digest of all that was then known in its several branches, and his impartiality in assigning to each contributor his appropriate share of merit.

At a time when no Treatise on Chemistry worthy of the name existed in Great Britain—when the greater part of what had been known in this country was obtained through the medium of translations from foreign languages, and when the facts recorded were put before us, often without much attempt at method or logical precision—Dr. Thomson surprised the world at an early age, by the publication of a System, in which the substances that came under his review were classified and arranged in such a manner, as to denote their mutual relations, and to exhibit the due subordination of their properties one to the other.

It may be doubted indeed, whether for the purposes of study, the analytical method of imparting knowledge, which he preferred adopting, is the one most advisable; it would rather seem, that instead of following, as he has done in his Treatise, the order of discovery, it might be better to commence with a statement of the general principles of the Science, and afterwards to enter in detail

upon the properties of the individual substances, whose phenomena have guided our predecessors to the general laws applicable to them all.

But admitting this as a defect in Dr. Thomson's arrangement, the clear and exact manner in which he reduced to order the facts scattered at the time he wrote over a thousand different publications, demands from us our warmest acknowledgments.

It may be difficult, indeed, to say, whether Dalton would have been able to establish the existence of those definite combinations between bodies upon which his Atomic Theory was mainly built, but for the laborious and accurate statements which Dr. Thomson had brought together in his Treatise, with respect to the composition of various salts. Nor ought it to be forgotten, that at the early period, when Wollaston received with hesitation, and Davy with ridicule, the theory which the penetration of Dr. Dalton had first pointed out, Thomson stood forward as its warmest advocate, and supported it with some of the most convincing of its proofs.

Nor were his services in diffusing knowledge confined to the accurate record of facts contained in his System of Chemistry. For nine years—namely from 1813 to 1822—he conducted the “Annals of Philosophy,” a Periodical in which he did not content himself with a mere publication of Essays on scientific subjects, communicated to him by others, or to a bare report of any new discoveries made in this or in other countries, but also introduced each year a Digest of the progress of Science in its various departments, in which the merits of each contributor were discussed with freedom, but always with perfect frankness, and with an entire absence of prejudice and party feeling.

In this undertaking, no less than in the first introduction of that system of symbolic writing which is now in common use amongst chemists, Dr. Thomson may be said to have pointed out two most efficient instruments for the advancement of his favourite Science.

The former proved the prelude to those comprehensive Reviews of the annual progress of Chemistry, which were for many years given to the world by Berzelius; the latter, after having been extended and improved by the distinguished Swede, found at length a general reception in the country in which it originated.

At a later period of his life, he published his “Attempt to establish the first Principles of Chemistry by Experiment,” a work which was censured by Berzelius, with a severity stimulated, no doubt, by the opposition between the results therein arrived at, and his own; although there may be some ground for alleging, that our con-

fidence in his accuracy is impaired by doubts as to the correctness of the data upon which he proceeded.

The work, however, must be allowed by all unprejudiced persons to exhibit marks of the most persevering industry, and to supply us with much valuable information.

For a candid review of its merits, I may refer you to Mr. Crum's excellent Sketch of the Life and Labours of Dr. Thomson, in which the author, without disguising the defects imputed to the treatise in question, or seeking to extenuate unduly certain errors which attach to the principle upon which the calculations in it are founded, successfully vindicates his former master from the charge of dishonesty, or at least of wilful carelessness in the conduct of his experiments, which had been most unfairly brought against him.

Whilst, however, I willingly leave this part of the subject in abler hands than my own, I cannot refrain from adding, that his adoption, in the work in question, of Dr. Prout's ingenious suggestion, that all other bodies were multiples of hydrogen, seems at length, notwithstanding the adverse verdict of the great Swedish chemist alluded to, and of others respecting it, borne out with regard to oxygen, carbon, azote, and calcium, by the elaborate researches of Dumas and Marignac, whilst other experimentalists appear to have since successfully reduced sulphur, zinc, silver, mercury, and iron to the same standard.

And when we recollect, on the one hand, how numerous are the sources of error which may creep into the best devised series of experiments, and, on the other, how infinite are the chances against our arriving, by any erroneous and therefore fortuitous results, at numbers which turn out to be exact multiples of the atomic weight of hydrogen, the argument in favour of Prout's doctrine, founded upon the coincidence of the figures in the cases above cited, seems greatly to exceed in strength that which can be alleged against it, from the non-accordance between experiment and calculation in the instance of a few other elementary bodies.

As an Historian of Science also, Dr. Thomson's merits were of a high order, from his candour, frankness in expressing his opinion, and diligence in ascertaining facts; indeed, his biographical notices supply us with some of the most valuable records we possess, with respect to the lives and characters of Chemists in this and the last century.

As Professor of Chemistry at Glasgow, an appointment which he held from the year 1818 till the period of his death in the summer of last year, Dr. Thomson had the satisfaction of training many who

have done honour to the school which he instituted, either by their scientific, or their practical contributions to Chemistry. Need I mention the names of Graham, of Walter Crum, Hugh Colquhoun, Alexander Harvey, Johnston of Durham, of Clark, and of Stenhouse, as exemplifications of this fact; or remind you that my only motive for passing so lightly over this portion of Dr. Thomson's services is the fear of offending the modesty of some of his surviving pupils who may chauce to be present?

I cannot, however, terminate these remarks, without observing, that the career of Dr. Thomson affords to the young chemist a cheering proof of the advances that may be made in Science, even under great original disadvantages, by an understanding, solid rather than brilliant, and marked more by sagacity and common sense than by genius and originality; provided only these powers of mind are, as his were, concentrated through life upon certain special objects, and are stimulated into exertion by no more selfish and ignoble principle than the pure love of scientific truth.

We have also lost since our last Anniversary, Mr. John Sylvester, a gentleman eminent for his successful applications of the Science of Engineering to domestic purposes. He was the son of Mr. Charles Sylvester, the well-known author of the "Philosophy of Domestic Economy," the principles of which he applied with so much sagacity in the case of the Derby Infirmary, as thereby to establish his reputation as a civil engineer. It was no doubt in great measure to the attentive study of his father's theory and practice, that we may attribute the expertness which our late Fellow displayed in the execution of large works for warming and ventilating buildings, as well as the success which attended some of his inventions, as in the case of the Radiating Stove Grate, now in such general use.

Mr. Sylvester was particularly happy in his contrivances for warming the Arctic Discovery ships, sent out under Captains Parry, Ross, and others; and it is said that the Ridge and Furrow Roof, so successfully applied by Sir Joseph Paxton to the Crystal Palace, had been previously adopted by Mr. Sylvester in the forcing houses he constructed for Mr. Strutt of Derby, in the year 1844. He was also an accomplished amateur-draughtsman, and was much regretted by his personal friends for his many amiable qualities.

His decease in the August of last year was occasioned by an obscure complaint, from which he had for a considerable time been a sufferer.

In vacating the Chair, which I have had the honour to occupy during the last two years, I am happy to think I am leaving the Society in a satisfactory state, both as regards its present condition and its future prospects.

We have, indeed, at two or three of our Meetings been left without a supply of matter, an accident more likely to occur in a Chemical Society than in one of a more miscellaneous and discursive character; and, indeed, when we reflect how many bodies, medical, pharmaceutical, and agricultural, divide with us the fruits of the labours which are carried on by chemists, not to speak of the number of chemical papers, which, as I remarked in my last Address, are communicated by us to the Royal Society, and appear in its Transactions, we need not be surprised if the supply of matter has not always kept pace with the activity of our Members, or with the interest which the Science is exciting in the mind of the public.

The flow of original communications has indeed of late been somewhat of an intermittent character, sometimes copious, sometimes deficient; but it is but fair to add, that whenever a void has occurred at our Meetings, it has been so well filled up by discussions of a general scientific interest, as to leave to those who attended little reason to regret that no new series of researches had been submitted to them on those occasions.

Our Members, however, ought not to forget, that this Society has the first claim to the services and contributions of those enrolled in it; and that, even if the researches they are carrying on seem of that practical or technical character as to demand, in the first instance, a different destination, it may be for the mutual advantage of themselves and of the Society that they should be subsequently submitted to us, as the merits of the scientific principles they involve are nowhere likely to be so satisfactorily or so fully canvassed as at the Meetings held in this room.

It is, moreover, a subject of regret to me, that nothing should have been done during my Presidentship, either by myself or others, towards simplifying and methodising the existing nomenclature of organic substances, which at the present time seems to proceed upon no fixed basis, or, at least, is guided by such rules only as may exist floating in the minds of the leading chemists who have most advanced this part of their Science, and which have never yet been distinctly enunciated. In a communication made to the chemical lecturer of the British Association at Ipswich, two years ago, I took occasion to point out what those rules apparently were, so far as

could be gathered from the practice of the individuals alluded to; and by so doing, may perhaps flatter myself with having contributed somewhat, towards promoting that uniformity and consistency in the use of the terms selected for designating newly-discovered compounds, which is in many respects so desirable.

But the larger and more ambitious scheme which I had once contemplated—that of enlisting the leading chemists of the country, and of this Society in particular, in the attempt to frame a general system of nomenclature, which might embrace the whole of Organic Chemistry—I have been induced to postpone, from considering the unsettled state of certain fundamental questions, upon which so much of the terminology as well as of the notation of organic bodies is necessarily dependant.

The Society is watching with interest the development of those views, which have more than once been brought before our notice, “On the condition of Elements at the moment of Chemical Change,” views, which, if adopted, would tend to modify many of our ideas with respect to chemical or electric affinity; tending, as they do, to the conclusion, that the particles of an elementary body are held together, not by that force which we term cohesive attraction, but by a kind of chemical affinity brought about in them, as it is in the case of compound bodies, by certain differences in the electrical condition subsisting between their particles.

The ingenious speculations also of another of our colleagues, by the aid of which he explains in so novel a manner the theory of etherification, appear to be based upon a similar principle, inasmuch as, instead of that fixity which was supposed to be involved in the very idea of a stable and definite compound, they assume a constant movement amongst its particles, arising, as it should seem, from some difference in their electrical condition.

To such a view, indeed, I am myself the more reconciled, as it is quite in harmony with the speculations which I ventured to indulge in at the time of the publication of the last edition of my Atomic Theory.*

I then remarked, that “if the particles, into which heat is capable of resolving matter, when it assumes the gaseous condition, be themselves divisible into still minuter ones under the influence of chemical affinity; and if even the latter, perhaps, are composed of groups of atoms, rather than of single ones, it is conceivable that every one of these groups, within its own little world, should admit of such an

* Introduction to the Atomic Theory, p. 278.

alteration in the position of its respective particles, as may serve to affect the properties it possesses, and consequently its relations to other bodies ; although no one of these particles can separate itself from the group, of which it constitutes a part."

This intestine movement amongst the particles of a solid body seems likewise confirmed by the phenomenon of *allotropism*, and by the change of form, colour, &c., which occurs in many bodies after crystallization ; whilst on a larger scale, the same is attested by many circumstances remarked by geologists with regard to the formation of mineral veins ; the segregation of certain substances from the general mass of the containing rock ; and other molecular changes which appear to be taking place within the bowels of the earth.

And since this mobility of particles is extended even to those which constitute the mass of a solid body, the theories of chemists in this respect seem tending to the same point as those of geologists, inasmuch as the former suppose a continual oscillation in the molecules of a body, owing to the interchange which is taking place between them ; whilst the cosmogonists of the present day maintain the same with respect to the solid fabric of the globe, which their predecessors figured to themselves as the very emblem of stability.

The theory, however, which in the case before us is built upon this postulate, requires for its adoption such a revulsion in our ideas with respect to the relations between ether and alcohol, as would involve in the end a new nomenclature, as well as a fresh method of notation. We should be called upon to alter the atomic weights of all the other elements, by doubling the number of atoms of hydrogen assumed to be present in water ; and instead of regarding ether simply as the oxide of an hydrocarbon, and alcohol as its hydrate, we should have to figure to ourselves the former as produced from water, by the replacement of one of its hydrogen atoms, and alcohol by that of both.

Such a view of the composition of these and other allied bodies has, indeed, much to recommend it, and deserves, in my humble opinion, the attentive consideration of chemists ; but it is one thing to receive a new theory with favour, and to entertain it with attention ; and another to admit it so entirely into the category of established truths, as to mould all our other views in accordance with its principles.

In framing a system of chemical nomenclature, therefore, at the present moment, we should neither be justified in ignoring the existence of theories which have already taken a certain hold upon the minds of eminent chemists, both in this and in other countries ; nor

could we venture to propose them as the basis of our scheme, whilst still under discussion, and perhaps but imperfectly developed as yet even in the minds of the individuals who have promulgated them.

To discuss however, as they deserve, these and other theoretical views, which occupy so prominent a place in the Journal of our Society, would be impossible, without transgressing the limits which custom has hitherto assigned to your President's Anniversary Addresses.

Here, therefore, I might be inclined to pause : but lest it should be imagined that our Members are exclusively absorbed in the speculative departments of Chemistry, to the neglect of the practical, I will briefly allude to the important services rendered to the cause of agriculture by Professor Way, in the course of the various researches he has been carrying on in behalf of the Royal Agricultural Society ; and especially by the manner in which he has elucidated the problem relating to the absorbent power possessed by different soils with reference to manures, and in which he has traced to its principles the property which belongs to Clay, of arresting in their downward progress the organic matters present in the water which percolates the earth, and even of separating from this solvent its most valuable saline contents—namely, the ammoniacal and other alkaline constituents with which it may be impregnated. And this, too, he has shown to be done by means of a double decomposition carried on in apparent contravention of the received laws of elective attraction. A discovery of this kind is not less important from its practical applications, than it is interesting in its bearings on the general principles of the Science ; and although not announced in the pages of our Transactions, deserves to be mentioned as the fruit of the persevering researches of a chemist, who is enrolled in the list of our Fellows.

Nor will it, I hope, be deemed irrelevant for me to allude to the important application of Scientific Chemistry to the solution of certain Geological Problems, which has been carried out by one of the most distinguished of our Foreign Members.

Those who have taken the trouble of perusing my work on Volcanos, and especially the second edition of it, published in 1848, will recollect, that in bringing forward that theory which may be regarded as a revival, or perhaps a development, of the original hypothesis of Sir Humphry Davy, my professed object principally was that of enlisting the services of chemists in an attempt to elucidate a series of phenomena, which, although essentially chemical, had been hitherto, in a great degree, abandoned to geologists.

Indeed, since the time when Gay-Lussac published his "Remarks on Vesuvius," and that at which Sir Humphry Davy paid a cursory visit to the same spot, no chemist of European reputation appears to have made volcanos a subject of study; excepting Abich, to whom we owe the first lucid sketch of the chemical relations which volcanic and plutonic rocks bear to each other; and Professor Bischoff of Bonn, whose researches were, however, confined to extinct volcanos, such as those of the Rhine and Eifel.

Hence it is not to be wondered at, that the subject should be treated as though it were exclusively a mechanical problem, and theorised upon without any due appreciation of the interesting chemical phenomena which it presents to our notice.

It was this consideration more especially which led me, in my work on Volcanos, to give a prominence to those points which appeared to have been unduly neglected by others; and to advocate with more zeal than I might otherwise perhaps have felt inclined to do, a theory, which necessarily brought before us the nature of the gaseous, saline, and crystalline products, which proceed from the internal focus of its action.

That this was my object, will appear from some remarks which I made fifteen years ago, in my "Report on Mineral and Thermal Waters," undertaken at the request of the British Association for the Advancement of Science, and published in their Transactions.

"We ought," I observed "carefully to distinguish between that which appears to be a direct inference from observed fact, and what can at most advance no higher claim than that of being a plausible conjecture. The general occurrence of volcanos in the neighbourhood of the sea, and the constant disengagement of aqueous vapour, and of sea-salt from their interior, are facts that establish in my mind a conviction that water finds its way to the seat of the aqueous operations, almost as complete, as if I were myself an eye-witness of another Phlegethon, discharging itself into the bowels of the earth, in every volcanic district, as in the solitary case of Cephalonia."

"Nor is the access of atmospheric air more questionable than that of water; so that the appearance of hydrogen united with sulphur, and of nitrogen either alone or combined with hydrogen at the mouth of the volcano, seems a direct proof, that oxygen has been abstracted by some process or other from both."

"Having satisfied our minds with regard to the fact of internal oxidation, we naturally turn to consider what principles can have existed in the interior of the earth capable of abstracting oxygen from water, as well as from air; and this leads us to speculate on the basis of

the earths and alkalis, as having been instrumental in causing it. But in ascribing the phenomena to the oxidation of these bodies, we ought not to lose sight of the Baconian maxim, that in every well-established theory, the cause assigned should be not only competent to explain the facts, but also *known to have a real existence*, which latter circumstance cannot, of course, be affirmed of the alkaline and earthy metalloids, as having a place in the interior of the earth."

I should not despair of being able to show that such an hypothesis is still tenable; but it will be more profitable on the present occasion, as well as, I doubt not, more agreeable to my hearers, for me to point out the substantial additions which Professor Bunsen has supplied to our knowledge of this class of phenomena.

He has, in the first place, proved that the products of volcanic action—at least as they display themselves in that vast *focus* of internal energy which we observe in the Island of Iceland—consist only of two kinds of material: either a trachytic rock, consisting of a trisilicate of alumina, conjoined with a similar compound of silica with an alkali or alkaline earth; or else an augite rock, in which 1 atom only of silica is combined with 2 atoms either of alumina, protoxide of iron, lime, magnesia, potass, or soda.

Bunsen has given a formula, by which the proportion between these two constituents, in any given rock, may be readily computed; and hence concludes, that the products of volcanic action in Iceland are derived from *two* independent *foci*.

But the most interesting part of his researches relates to the changes which have been wrought upon these materials by causes of subsequent operation.

Few of the friends I see around me on the present occasion are old enough to have witnessed the contests which for many years were waged with so much fury between the advocates of the igneous and aqueous origin of basalt.

In this controversy much stress, I recollect, was laid by the Wernerians on the characters of trap-tuff, which, it was contended, could by no means admit of being referred to the action of heat, whilst its passage into trap-rocks rendered it difficult to ascribe to the one an origin which was denied to the other.

Now, Professor Bunsen has, in the first place, beautifully shown that the species of tuff, which prevails in Iceland, and which is also abundant in Sicily, as is implied by its name *Palagonite*, derived from the village of Palagonia at the base of Etna, possesses such a chemical composition as identifies it with the pyroxenic rock of the neighbourhood.

He has also succeeded in explaining those differences in structure and in appearance, which, in spite of this correspondence in the nature of its constituents, stamp it as a distinct mineral; having traced such alterations to the operation, not indeed of water alone, but of an alkali, or an alkaline earth, containing just so much water as to exist in the condition of a hydrate, formed in either case by the influence of a temperature equal to that of ignition.

The Professor states, that he has actually succeeded in converting basalt into palagonitic tuff, by mixing it in a state of fine powder with 13 times its weight of slaked lime, or of potass.

Thus, the very alkali, which may have been sublimed from some internal *focus* of igneous action, might, if water were also present, have been instrumental in converting an ordinary pyroxenic rock into palagonite under the influence of heat.

Another difficulty which besets the Huttonian theory, arose from the existence of zeolites in the midst of rocks of supposed igneous formation; as the readiness with which these minerals part with their water, seemed inconsistent with the supposition of their originating at a high temperature.

This was got over by supposing such minerals to have been formed under a pressure sufficient to prevent the water from escaping, and hence the Vulcanists were in some cases driven to assume pressure, where none could be shown to have existed.

But Bunsen has relieved them from this embarrassment, by demonstrating, that zeolites may be generated, by fusing lime and silica with an excess of caustic potass, without any pressure at all; and that by this method crystals may be produced at a red heat containing water, of which, however, the greater part is disengaged at a temperature not exceeding 228° , when the substance is detached from the crucible in which it had been formed.

Professor Bunsen has also, by a series of decisive experiments, removed all doubts as to the nature of the aeriform bodies which are disengaged from volcanos, and has fully substantiated, what my own observations, and those which I had collected from various other sources, led me to infer—namely, that inflammable gases, made up, either wholly, or in part of hydrogen, are amongst the most constant concomitants of volcanic action in all its various phases. Nitrogen also, often unaccompanied with oxygen, seems to be as common in the fumaroles of Iceland, as I have found it to be in the thermal springs of other volcanic regions.

And with respect to the origin of these gases, Bunsen most satisfactorily refutes the idea of his countryman Bischoff, who refers them to the spontaneous decomposition, or dry distillation of organic

matters, showing that when this process takes place, nitrogen is invariably accompanied with marsh gas and other hydrocarbons which are never present in volcanos.

He accordingly expresses his decided opinion, that the objections which have been supposed to be fatal to the old volcanic theory of Davy, entirely lose their value after these results. "For if," he remarks, "in the spirit of this theory, it is assumed, that the lavas, and the phenomena of ignition accompanying them, result from an oxidation of alkaline and earthy metals, determined by a decomposition of water, it admits of being proved, that the quantity of the hydrogen evolved from volcanos, bears a perfect relation to the magnitude of the streams of lava formed."

A single one of the vapour springs of Krisuvik yields, according to Bunsen's own calculations, about 12 cubic metres of hydrogen in 24 hours.

"Assuming, then, that the remaining innumerable springs, together with the large fumaroles occurring there, yield together a quantity only 100 times as great—which may safely be regarded as far less than the quantity of this gas which is actually evolved—we may, by means of this assumption and simple calculation, show, that the formation of lava, which would be equivalent to such an evolution of gas within the period which elapses between two great eruptions, is sufficient to produce immense streams of lava."

"Nor is it any longer possible to attach importance to the second of the principal objections which have been made to Davy's hypothesis—namely, that it is unusual to observe any sensible appearance of flames during great volcanic eruptions. For if, from the known composition of the first-mentioned fumarole gas, we estimate the temperature of its flame, we find it to be $305^{\circ}6$; consequently, a temperature which is far below the point of ignition of hydrogen. These gases are, therefore, combustible only at a red heat, and even under the most favourable circumstances can only produce by such a combustion an increase of temperature amounting to $305^{\circ}6$, which in a red heat must necessarily escape altogether observation by the eye."

Satisfied with having obtained the weighty testimony of Professor Bunsen in favour of the facts which I had alleged in confirmation of the theory to which I had given my adhesion, I shall the less regard the opposition that exists between my views and his with respect to the source of the hydrogen evolved.

Professor Bunsen derives this gas from the process in which pyroxenic lava is converted into palagonite through the agency of the

hydrates of the alkalis or alkaline earths, assisted by a high temperature, during which, as he has shown, hydrogen is evolved; and he even shows that if sulphur in vapour be brought into contact with basalt at a high temperature, and afterwards steam be passed over the rock so treated, sulphurous acid is disengaged in the first instance by the union of the sulphur with the oxygen of the peroxide of iron, which metal forms, with another portion of the same body, sulphuret of iron; and that sulphuretted hydrogen will be emitted in the second instance, owing to the decomposition of water, and the union of its hydrogen with the sulphur of the pyrites, whilst its oxygen forms, with the metallic portion, magnetic oxide of iron.

Supposing the formation of palagonite to be going on at all times when sulphuretted hydrogen and pure hydrogen can be shown to be concomitants of the volcanic action, and on a scale commensurate to the amount of gas generated, the explanation of Professor Bunsen will probably be accepted by chemists in general, in preference to that which refers it to the decomposition of water by alkaline and earthy metalloids, or their yet unoxidized sulphurets; but I cannot admit, as a valid objection to this latter hypothesis, the absence of carbonic oxide from volcanic exhalations of which carbonic acid constitutes so large a proportion. No doubt the latter would, as Bunsen remarks, be partially converted into carbonic oxide by hydrogen at the high temperature which probably exists around the *focus* of the volcanic action; but I have always been accustomed to refer the carbonic acid given off by volcanos to the diffusion of heat over contiguous limestone rocks, and not to processes going on at the point where the temperature was most intense.

Nor do I feel quite satisfied with the explanation offered by the Professor, of the presence of sal-ammoniac in the lava, which he refers to the vegetable matter existing in meadow-land overflowed by the molten current. If such were the origin of the volatile alkali, we ought not to find it exhaled round the orifices of the crater, or from any of the fumaroles proceeding directly from the same internal *focus* of action.

It is not my purpose, however, especially on such an occasion as the present, to criticise the labours of this eminent chemist, or to dwell upon those points in which the results of my own humbler inquiries in the same field of research may clash with his. It is sufficient for me to have pointed out to you his Memoirs on the subject of the Iceland Volcanos, as an important present rendered by Chemistry to the sister Science of Geology; and as a service too,

which those who turn away with indifference from researches of a more refined nature, lying strictly within the domain of pure chemistry, would be likely to accept as an undeniable evidence of the extensive utility of our pursuits.

It is, indeed, a fortunate circumstance, in more respects than one, when such happy applications of chemical principles to other departments of natural knowledge are carried out by those of our brethren, who had before established their reputation amongst ourselves, by researches which chemists, and chemists only, are capable of appreciating.

No geologist, at least, can feel, that he has a right to impugn as visionary, conclusions, which have been deduced by a philosopher, who had before attained the first rank amongst experimentalists, by his profound and intricate investigations into the members of the Cacodyle series; just as for the same reason no candid mind can fail to pay deference to the suggestions of another of our foreign associates, on questions relating to physiology, agriculture, and the like; knowing, that before that eminent philosopher had turned his attention to these subjects, he had already earned a great name amongst chemists, by the success with which he had grappled with the most difficult problems in Organic Chemistry; and by the flood of light which he had shed over a class of bodies, before comparatively unattractive, owing to the obscurity which enveloped their real nature, and the absence of those connecting links, the discovery of which by himself, more than perhaps by any other single individual, has shown that they constitute the parts of one harmonious and unbroken series.

And now, Gentlemen, nothing more remains, except that I should express my most cordial thanks to you all, for the kindness and courtesy I have ever experienced since I began to fill the honourable office which you conferred upon me; and to the Members of the Council more especially for relieving me, as they have done, by their close attention to your affairs, from the most onerous portion of my duties. It is also satisfactory to me, on relinquishing the Chair, to reflect, that in selecting Colonel Yorke as my successor, you will place at your head a zealous Member of the Society, who, as being resident amongst you, will have the power, far more efficiently and more regularly than I have found myself able to do, of watching over your interests, and of presiding at your Meetings.

NOTICES

OF

PAPERS CONTAINED IN OTHER JOURNALS.

On the General Distribution of Iodine.

By Stevenson Macadam.

(COMMUNICATED BY THE AUTHOR.)

During the last twelve months I have been engaged in a series of experimental researches as to the general distribution of iodine and bromine.

My attention was first drawn to this subject by the announcement recently made by Chatin, that he had detected the presence of iodine in the atmosphere, in rain-water, and in snow.

Believing that if iodine were present in the media referred to, its neighbour-element bromine would be found there too, I was induced to undertake the investigation, partly with the hope of being able to corroborate the results communicated by Chatin in reference to iodine, but principally with a view to determine whether an appreciable quantity of bromine was present in the atmosphere.

Several minor experiments, in the course of which I subjected to examination quantities of air ranging from 150 to 4000 cubic feet, having given a negative result so far as the detection of iodine and bromine were concerned, I at length undertook an experiment during which 100,000 cubic feet of air were transmitted through—

1st. A tube containing slips of starched paper.

2nd. A gas-bottle containing iron-filings and water, and

3rd. A similar bottle with solution of acetate of lead.

The starched papers and the liquid with iron-filings were intended to retain any *free* iodine, and the lead-solution any soluble iodide. At the conclusion of the experiment, and when 625,000 gallons of air had been passed through the arrangement, it was found that the papers were not sensibly altered in tint, and that neither the water in which the iron-filings were suspended, nor the solution of acetate of lead contained the slightest trace of iodine.

I do not purpose to take up the time of the Society by minutely detailing the several steps of the process to which the liquids obtained at this and other parts of the inquiry were subjected; suffice it to

say, that in every instance when the final testing of the solution was arrived at, I determined the presence or non-presence of iodine by aid of starch, nitrite of potassa, and hydrochloric acid.

Whilst these experiments on the atmosphere were proceeding, I was examining large quantities of rain-water which had fallen in different districts of Scotland.

In some instances, acetate of lead was simply added to the water, and the whole evaporated to dryness; in other cases, iron-filings were first added, and the liquid, after being agitated with an iron rod, was treated with acetate of lead, evaporated to dryness, and subsequently tested. In no instance, even when employing 12 gallons of water at one time, was there any indication of iodine.

Twelve gallons of water obtained from snow collected in the centre of Edinburgh, also 12 gallons from snow which had fallen in the country (at Pennecuik), ten miles south of that city, and 12 gallons from the neighbourhood of Innerleithen, thirty miles south of Edinburgh, were severally treated with iron-filings and acetate of lead, and no iodine was found. The liquids ultimately obtained from the three quantities of snow-water, and which had been used in the starch-testing, were added together, neutralized with an alkali, evaporated to dryness, and carefully charred to decompose the starch; the liquid obtained from this, and which represented 36 gallons of snow-water, did not exhibit the slightest indication of the presence of iodine.

In these experiments I was anxious to employ reagents which were perfectly free from iodine, and therefore refrained from using the fixed alkalis to any extent, although Chatin's papers lead me to believe that they were largely employed by him. The quantity of iodine in potashes seems to decrease by each refinement, but I have never yet encountered a sample of potash in which I did not find iodine when it was sought for. The purest is that obtained by calcining the bitartrate of potash. I have had occasion several times to use small quantities of the alkali thus obtained, and although the presence of iodine could not be detected in 2 ounces of a strong solution, yet in 6 ounces a trace was visible.

The negative results of these experiments lead me to believe that in the air, in the rain-water, and in the snow employed by me, there was not an appreciable quantity of iodine.

Before parting with this part of my subject, I may state that I am well aware that several communications have lately been laid before the Academy of Sciences which tend to verify the accuracy of Chatin's results; but one and all of them are objectionable, from the authors having employed potash and other materials which there is every reason to believe would contain iodine originally.

Marchand employed nitrate of silver, hyposulphite of soda and bicarbonate of potash; Grange, chloroform and caustic potash. Barral, in his late admirable researches on the atmosphere, failed to

detect iodine in the rain-water which falls during January, February, March, April and May, but found a very small quantity in that of June. I have not seen a report of the process employed by him, but think it probable that he used the materials derived from some of his nitric acid experiments, and to which he had added caustic potash in order to fix the nitric acid.

So far as regards the process adopted by myself, it is worthy of remark, that Thénard, in commenting upon the researches of Chatin, recommends that the metals most susceptible of being iodized should be exposed for some time to the action of the air. Some months previous to this suggestion being read to the Academy of Sciences, I had used iron and lead in the search for iodine, and ten days prior to the date of Thénard's paper, a report of some of my experiments was published in the Edinburgh Philosophical Journal, in which the use of the metals was clearly stated.

Every trial for free iodine was accompanied by a search for bromine, but the result was, in every instance a negative one, so far as the atmosphere, rain-water and snow are concerned.

Whilst differing from the views expressed by Chatin in reference to the atmospheric distribution of iodine, I very willingly agree with him in considering that this element will be found more generally distributed in the vegetable kingdom than it has formerly been supposed to be. In 45 plants, hitherto unknown to contain iodine, I have discovered that element. Amongst that number there are representatives from different districts of Scotland, and also different altitudes, from the level of the sea to some 1600 feet above it.

The determination of the presence of bromine in plants is somewhat more difficult, owing to the tests for that element being much less delicate in their action than the starch-test for iodine.

With the exception of the announcement of the presence of bromine in the ammoniacal liquids of the gas works, in plants of the family of *Oscillariæ* growing in thermal waters in the south of France, and a trace in carbonate of potash, I am not aware that the element in question has been shown to be a constituent of inland plants. In the greater number of plants tested by me, not a trace of bromine could be detected; but in potashes, in the ashes of the pear, the gooseberry and the apple-trees, I obtained very distinct evidence of the presence of this element. The tests I relied upon were the odour, the yellow colour imparted to ether, and the production (to a greater or less extent) of the brown-red bromide of gold.

The failures which I encountered when testing for bromine in the majority of plants, I am inclined to ascribe to the small quantity of plant ashes which were at my disposal.

In conclusion, I would state that the presence of iodine and bromine in plants, more especially in the edible ones, implies that these substances are introduced into the system of even the highest animal,

and though as yet unsuccessful, yet I trust that before long I shall be able to determine the presence of both these elements as normal constituents of the animal frame.

On a new Oxide of Hydrogen, and its relation to Ozone.*

By M. Baumert.

This investigation relates chiefly to the volatile substance obtained in the electrolysis of water, and commonly known by the name of ozone. As, however, this body is commonly regarded, without any positive proof, as identical with the substance produced when electric sparks are passed through gases containing oxygen, it became necessary to consider the latter simultaneously with the former. The author, however, abstains from giving any opinion as to the nature of ozone produced by processes not electrical.

Since ozone, as produced by the electrolysis of water, is independent of the substances which are added to the liquid to make it conduct, we may conclude at once that it contains nothing but oxygen and hydrogen. The quantity varies indeed with the nature of the substances so added; but the production never fails when substances are added which are not readily susceptible of any higher degree of oxidation, such as sulphuric, phosphoric, or chromic acid.

That ozone thus obtained contains hydrogen as well as oxygen, may be demonstrated by passing it through a long glass tube, the inner surface of which is coated with a thin film of anhydrous phosphoric acid (this coating is most easily produced by passing through the tube a stream of dry air, carrying with it a quantity of finely-divided phosphoric acid, produced by the recent combustion of phosphorus). If the ozone be perfectly dry, the phosphoric acid will remain unaltered; but if the middle of the tube be gently heated, and the ozone thereby decomposed, the water then formed dissolves the anhydrous phosphoric acid on that side of the flame which is farthest from the end of the tube at which the gas enters, whilst the acid on the other side remains unaltered. It appears, then, that ozone contains the elements of water; and its powerful oxidizing properties show that these elements are combined in it with excess of oxygen.

If, then, a method can be found of estimating the oxygen which, in combination with the elements of water, forms ozone, it will only be necessary in addition to weigh the ozone in its entire state, in order to arrive at a complete knowledge of its composition. The excess of oxygen may be estimated by a method essentially the same as that adopted by Professor Bunsen in the analysis of iodide of nitrogen (see page 90, of this volume). For the oxygen combined

* Pogg. Ann. LXXXIX. 38.

with the elements of water in ozone separates an equivalent quantity of iodine from a solution of iodide of potassium, just as chlorine or bromine does. It is only necessary, therefore, to determine the quantity of iodine thus separated, and the proportionate quantity of oxygen will be known immediately.

A solution of iodine in iodide of potassium is prepared, of such a strength that the quantity of iodine in a degree of the burette shall be only a small fraction of a milligramme = a (e.g., in the following experiments, = 0.0002538 grm.) A quantity of extremely dilute sulphurous acid is also prepared, containing not more than $\frac{3}{100000}$ of the acid. It is next to be determined how many burette-divisions t , of the iodine-liquid are required to decompose a given volume of this sulphurous acid. The quantity of iodine required for this purpose is $a t$. If, now, n measures of this sulphurous acid be added to the iodine-liquid which has been treated with ozone, which latter contains the quantity x of iodine sought, this quantity x will decompose a certain portion of the sulphurous acid. Lastly, if the number of burette-degrees t' , and thence the quantity of iodine $a t'$ be determined, which is required for the complete decomposition of the n measures of sulphurous acid, we have the equation :

$$x + a t' = n a t,$$

whence

$$x = a (n t - t').$$

The point at which the decomposition of the acid is complete may be readily ascertained by Dupasquier's method with solution of starch. From this quantity x , which is the quantity of iodine set free by the oxygen in the ozone, the quantity w of oxygen which the ozone contains, in addition to the elements of water, may be readily calculated by the equation

$$w = \frac{O}{I} a (n t - t').$$

To determine the total weight of the ozone, it is passed, after being thoroughly dried, into a small bulb-apparatus, containing solution of iodide of potassium, and having attached to it a tube or another bulb-apparatus containing sulphuric acid, to condense the water which evaporates. The increase of weight in this apparatus gives the total weight of the ozone required.

The preparation of the ozone presents considerable difficulties. It acts so rapidly on all organic substances, that any corks or caoutchouc used to connect the different parts of the apparatus are quickly eaten through; hence it is necessary to make all the connections by fusion or by grinding. Notwithstanding this rapid action, the quantity of ozone produced is very small, so that large quantities of water must be decomposed in order to produce the required amount of ozone. In one experiment, in which 76 grms.

of water, acidulated with $\frac{1}{10}$ sulphuric acid were decomposed, 150 litres of detonating gas were found to contain 1 milligrm. of ozone. Chromic acid solutions, containing a little sulphuric acid, yield, however, a larger quantity—viz., about 1 milligrm. in 10 litres of detonating gas. The presence of free hydrogen in the ozoniferous gas must be carefully avoided; otherwise the excess of oxygen in the ozone will combine with the hydrogen, and form water. Hence it is necessary to collect apart the gases evolved at the positive pole—viz., the oxygen and ozone. This is effected by a peculiar arrangement, for a description and figure of which we must refer to the original memoir. The ozoniferous oxygen is then passed through a long tube, containing pieces of pumice-stone soaked in oil of vitriol, and thence into the bulb-apparatus already mentioned, containing the solution of iodide of potassium.

The oxygen, which in the ozone is combined with the elements of water, decomposes the iodide of potassium, setting free an equivalent quantity of iodine, and forming caustic potash. Hence the solution soon assumes a brown colour. This, however, disappears again, because the iodine, thus separated, acts upon the potash, forming iodide of potassium and iodate of potash, which salts, after a while, form a crystalline crust on the dry part of the bulbs. When such a solution, which likewise contains free iodine, is mixed with hydrochloric acid, the iodine of the iodate of potash is again completely separated. Hence the quantity of iodine separated by the oxygen may be determined with equal precision, whether it remains uncombined or forms iodate of potash.

Exp. 1. Current continued for 6 days. Total weight of ozone, $A=0.0133$ grms.; $a=0.00025387$; $t=55.1$, $t'=44.4$; $n=10$.

Hence $w=0.008109$; $A-w=0.01191$.

Exp. 2. Current continued for 8 days. Total weight of ozone, $A=0.0419$ grms.; $a=0.00025387$; $t=246.5$; $t'=121.8$; $n=3$.

Hence $w=0.009887$; $A-w=0.005013$.

These numbers agree best with the formula HO_3 .

Calculated.				Found.		
H . . .	1	4		4.34	3.76	4.30
3 O . . .	24	96		95.66	96.24	96.00
HO_3	25	100		100.00	100.00	100.00

We have then the following three oxides of hydrogen :

Water = HO
 Binoxide of hydrogen . = HO_2
 Ozone = HO_3

From the position which ozone occupies in this series, it might be

regarded as an acid, and called not inappropriately, *hydrogenous acid*. Viewed in this light, it exhibits a certain analogy with nitrous acid. That which is sometimes the case with nitrous acid, appears always to happen with ozone—viz., that it is decomposed by direct contact with bases. Hence it has not yet been found possible to produce any saline compounds of ozone. The chemical relations of this body are, in fact, much more those of a peroxide of hydrogen. Metallic oxides, susceptible of higher oxidation, are converted by it into peroxides and acids. Ammonia is converted into a nitrate, and mercury into mercuric oxide, without forming a salt. On the oxides of the magnesium group of metals it appears to exert no action. The colour of litmus is destroyed by it without previous reddening. Generally, ozone, in contact with easily oxidable substances, gives up its oxygen, and water is separated. This behaviour renders it necessary in preparing ozone, to get rid of the hydrogen simultaneously evolved from the water. Experiments in which detonating gas was passed through the apparatus above described, constantly gave by analysis an excess of water. Now, as in these experiments the other conditions remained the same, this formation of water can only be explained by a direct combination of the free hydrogen with the excess of oxygen in the ozone.

From all that has been said, it may be regarded as certain that hydrogen exists in ozone as an essential constituent. The amount of hydrogen found in the preceding experiments cannot have proceeded from aqueous vapour mechanically carried forward; for the gas, before entering the bulb-apparatus, had passed through a tube containing sulphuric acid five times as long as that which it traversed immediately before emerging from the apparatus. If, then, the increase of weight in the bulb-apparatus had been due to water mechanically carried forwards, it would have been less than the amount corresponding to the weight of oxygen determined by the graduated solution, certainly not greater. Another objection which might be made to these experiments is based upon the tension of the sulphuric acid vapour, which might possibly have been sufficient to carry free sulphuric acid into the iodide of potassium apparatus, together with the gases. To obviate this objection, the author passed 50 litres of atmospheric air in a rapid current through the drying-tube, placing at the end of it a bulb-apparatus filled with distilled water. At the end of the experiment, the water did not show the slightest turbidity with chloride of barium.

Considering the doubt which exists as to the identity of the several bodies included under the general name of ozone, it must be regarded as yet uncertain whether the substance produced by the passage of electric sparks through dry oxygen gas is identical with the compound above examined. If it be so, the formation of the

latter can only be explained by supposing that the dried gas still retains traces of moisture. If, on the contrary, it can be shown that the odorous substance produced by the electric spark in an atmosphere perfectly freed from aqueous vapour, is really oxygen, brought by the enormous but momentary rise of temperature caused by the electric spark, into an allotropic condition characterized by increased combining energy, then it is easy to establish a very simple relation between this allotropic oxygen and the ozone, which has just been shown to be a peroxide of hydrogen. In that case, indeed, the latter must be regarded as water oxidized at the expense of the allotropic oxygen, and must therefore always be formed when this allotropic oxygen comes in contact with water at comparatively low temperatures; the odour of the allotropic oxygen being, in fact, actually due to the formation of ozone. This question will be decided in the affirmative, if we can show that *perfectly* dry oxygen through which the electric spark is passed, actually acquires a combining tendency, strong enough to overcome the most powerful affinities, such as those of chlorine and iodine for potassium, at ordinary temperatures. For this purpose, the apparatus above described was modified as follows:

The ozonized oxygen evolved from the positive pole of the battery was passed, first through a small bulb-apparatus, containing sulphuric acid; thence into a glass tube *a*, surrounded at its middle part with platinum foil, and heated by a spirit-lamp to a temperature sufficient to decompose the ozone, and separate it into water and free oxygen. The gas was made to pass into a bulb *b*, containing pieces of iodide of potassium, and thence into a long tube *c*, filled with chemically pure, anhydrous phosphoric acid. The gas thus freed from ozone and aqueous vapour passed next into a glass tube *e*, the part of which nearest the drying tube *c* was widened, and had two platinum wires inserted through its sides, by means of which a rapid succession of electric sparks from an induction apparatus could be passed through the gas. The inner surface of this tube was coated with a thin film of phosphoric acid, in the manner described on p. 169. Lastly, to the other end of this tube was attached a bulb-apparatus, containing solution of iodide of potassium.

The mode of experimenting was as follows: The ozonized oxygen from the battery was passed for three hours through the apparatus with moderate rapidity, the tube *a* being kept red-hot all the while, and the induction apparatus not being in action. Neither the iodide of potassium in the bulb *b*, nor the phosphoric acid in the tube *e*, exhibited the slightest alteration. Now, the author has found that a film of phosphoric acid attached to the inside of a tube, as above described, will detect the presence of $\frac{1}{1000000}$ of a milligram of watery vapour; moreover, as 4000 cub. cents. of gas passed through the

apparatus in four hours, it follows that 1 cub. cent. of the gas could not have contained $\frac{1}{10000000}$ of a millgrm. of water. The iodide of potassium in the bulb-apparatus not only remained perfectly colourless, but did not even exhibit a trace of blue colouring on the addition of hydrochloric acid and starch; showing that the ozone had been completely decomposed in passing through the former parts of the apparatus.

The experiment was next repeated, with this difference, that the induction apparatus was set in action, and a rapid succession of sparks passed between the wires in the tube *e*; as, however, a certain quantity of nitrogen had entered into this tube on the previous removal of the bulb-apparatus, the stream of oxygen was continued for a sufficient time to drive it all out before the induction apparatus was set going. Without this precaution, the result might have been vitiated by the formation of nitric acid. In a few minutes after the sparks began to pass the iodide of potassium solution became sensibly yellow, and after an hour, a millgrm. of free iodide could be detected in it. During the whole experiment, the film of phosphoric acid in the tube *e* did not exhibit the slightest change.

The bulb-apparatus was then filled for the third time with fresh solution of iodide of potassium, and any nitrogen that might have entered, expelled as before. The induction apparatus was then set in action, and the experiment repeated in the same manner, excepting that the part of the tube *e* nearest to the bulb *f* was heated by a small spirit-lamp. Under these circumstances, the iodide of potassium solution did not exhibit the slightest change of colour; and even after the lapse of an hour, the addition of hydrochloric acid and starch did not produce the slightest bluing. On detaching the bulb-apparatus, the gas which issued from the tube *e* did not exhibit the faintest odour; but as soon as the spirit-lamp was removed, a very strong smell of ozone became perceptible; ceasing, however, as soon as the passage of the sparks was interrupted, and again becoming perceptible on the instant of their removal.

The quantity of iodine set free in the last experiment but one in the course of an hour, was more than nine times as great as would correspond to any increase of weight in the apparatus resulting from aqueous vapour mechanically carried forward. Hence we may conclude, that there really exists an allotropic oxygen, which, at ordinary temperatures, exhibits a strength of affinity exceeding that of chlorine.

The conditions under which this allotropy of oxygen occurs are very remarkable. In nearly all other bodies, the allotropy produced by elevation of temperature is characterized by diminution of chemical energy. In this case, however, we see a condition distinguished by an increase of combining tendency produced by a rise of temperature of the greatest intensity and shortest duration. It is no less re-

markable, that this state is produced at the highest temperatures only, and when once produced, is destroyed at a temperature of about 200°C . The conversion of allotropic into ordinary phosphorus is not momentary, but requires a certain time. In a similar manner, it is probable that oxygen which has been brought into the allotropic state by the high temperature of the electric spark, may, when quickly cooled, sink from that temperature to 200° without being completely brought back to its original state; provided that the time occupied in the cooling be shorter than that which is required to produce the change within that particular range of temperature. Hence we may understand why it is that so small a fraction only of the total quantity of oxygen remains permanently in the allotropic state, and how this state so quickly disappears at a heat of 200° . The temperature at which ozone is resolved into oxygen and water will probably be found to differ from that at which allotropic oxygen is converted into the ordinary variety. On this point the author hopes to have something further to communicate.

On Piperidine, a New Alkali derived from Piperine.*

By A. Cahours.

Rochleder and Wertheim found† that when a mixture of piperine and soda-lime is heated, an oily volatile base is evolved, possessing all the properties of *Picoline*; this compound they were induced to regard as a pseudo-salt containing the elements of picoline united with a quaternary organic group of atoms.

M. Cahours, being desirous of making a comparative study of picoline and the isomeric base aniline, distilled, according to the recommendation of the chemists above-mentioned, 1 part of piperine with $2\frac{1}{2}$ to 3 parts of potash-lime. The product of the distillation, collected in a cooled receiver, consisted of water, of two distinct volatile bases, and a neutral substance possessing an agreeable aromatic odour, like that of the derivatives of the benzoic series. When this crude liquid is treated with fragments of caustic potash, a light oily substance separates, having a strongly ammoniacal odour, and dissolving in all proportions in water. This oil, when distilled, passes over almost wholly between 105° and 108°C .; but towards the end of the distillation, the thermometer rises rapidly to 210° , and there remains stationary. The more volatile product, which forms more than $\frac{9}{10}$ of the crude liquid, distils over entirely at 106° , when rectified anew. This substance, which possesses all the characters of a definite compound, is a colourless, very limpid liquid, having a strong

* Ann. Ch. Phys. [3] XXXVIII, 76.

† Ann. Ch. Pharm. LXX, 58.

ammoniacal odour, but recalling also that of pepper; it blues red-dened litmus strongly, has a very caustic taste, and saturates the most powerful acids. It dissolves in all proportions in water, to which it communicates very decided alkaline properties. The solution behaves like ammonia with saline solutions, excepting that it does not appear to redissolve the oxides of copper and zinc.

By reason of its origin, the author designates this base by the name of *Piperidine*.

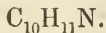
The analysis gave the following results :

Calculation.				Experiment.				
				I.	II.	III.	IV.	
10 C	.	.	60	70·58	70·46	70·31	—	70·48
11 H	.	.	11	12·94	12·96	13·03	—	13·05
N	.	.	14	16·48	—	—	16·60	—
C ₁₀ H ₁₁ N	.	.	85	100·00				

From these numbers it appears that the simplest formula by which the composition of the base can be expressed is C₁₀H₁₁N; to determine whether the rational formula is really expressed by these numbers or by a multiple of them, the vapour-density was taken. Experiment showed it to be 2·958. Now supposing that the preceding formula represents 4 vols. of vapour, we have :

$$\begin{array}{rcl}
 10 \text{ vols. Carbon-vapour} & = & 8\cdot440 \\
 22 \text{ ,, Hydrogen . .} & = & 1\cdot522 \\
 2 \text{ ,, Nitrogen . .} & = & 1\cdot944 \\
 \hline
 & & 11\cdot906 \\
 & & \underline{\quad 4 \quad} = 2\cdot976
 \end{array}$$

The equivalent of piperidine is therefore actually represented by the formula



This base forms perfectly crystalline compounds with hydrochloric, hydrobromic, hydriodic, sulphuric, nitric and oxalic acids.

The *Hydrochlorate*, C₁₀H₁₁N, HCl, forms long colourless needles, very soluble in water and alcohol; from the alcoholic solution it separates in long prisms. The crystals volatilize when moderately heated, and are not altered by exposure to the air.

Hydrochlorate of piperidine forms with chloride of gold a crystalline powder, composed of small needles of a fine yellow colour, and with bichloride of platinum a compound which crystallizes in orange-coloured needles, having the composition C₁₀H₁₁N, HCl, PtCl₂. This salt is very soluble in water, less soluble in alcohol.

Hydriodate of Piperidine, $C_{10}H_{11}N$, III, crystallizes in long needles, resembling the hydrochlorate.

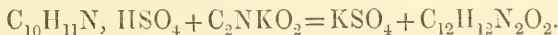
Nitrate of Piperidine, $C_{10}H_{11}N$, HNO_3 , forms small crystalline needles. It is obtained by saturating the base with weak nitric acid, and evaporating *in vacuo*. It is decomposed by heat, giving off vapours which have an aromatic odour. Alcohol dissolves it readily.

Nitrous acid acts violently on piperidine, forming a heavy aromatic liquid, which the author did not obtain in quantity sufficient for analysis. From the results obtained by Hofmann,* on the mutual action of nitrous acid and aniline, it is probable that the action just mentioned gives rise to the formation, first of the compound $C_{10}H_{10}O_2$, and then of $C_{10}H_9NO_4 \} O_2$.

Oxalate of Piperidine, $C_{10}H_{11}N$, C_2HO_4 , is formed by saturating piperidine with a solution of oxalic acid; it separates by evaporation in delicate needles, which may be obtained pure by a second crystallization.

Sulphate of piperidine, $C_{10}H_{11}N$, HSO_4 , obtained directly by saturating piperidine with sulphuric acid, is a crystallizable salt, deliquescent, and therefore very soluble in water.

Piperidic Urea.—When sulphate of piperidine is boiled with an equivalent quantity of cyanate of potash, sulphate of potash is formed, together with a compound analogous to urea:



To separate the latter compound, the liquid is evaporated to dryness, the residue digested in strong alcohol, and the alcoholic solution left to evaporate; the piperidic urea is then deposited in long white needles:

	Calculation.	Mean of experiments.
12 C . . .	72 56.25	56.32
12 H . . .	12 9.37	9.41
2 N . . .	28 21.87	22.05
2 O . . .	16 12.51	—
$C_{12}H_{12}N_2O_2$. .	128 100.00	

This compound is also formed when cyanic acid vapour is passed into piperidine. A solid mass is then obtained, soluble in water and alcohol, and possessing all the characters of the compound just described.

If, instead of cyanic acid vapour, cyanate of methyl be passed into the solution, an analogous compound is obtained, which bears the same relation to the preceding that methyl-urea bears to ordinary urea:

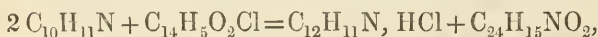
* Chem. Soc. Qu. J. III, 231.

This latter compound is in fact, *Piperidic Methyl-urea* = $C_{12} \left\{ \begin{smallmatrix} H_{11} \\ C_2 H_3 \end{smallmatrix} \right\} N_2 O_2$; its formation is expressed by the equation $C^2N (C_2H_3) O_2 + C_{10}H_{11}N = C_{14}H_{14}N_2O_2$. Similarly, cyanate of ethyl with piperidine forms *Piperidic Ethyl-urea* = $C_{16}H_{16}N_2O_2 = C_{12} \left\{ \begin{smallmatrix} H_{11} \\ C_4 H_5 \end{smallmatrix} \right\} N_2 O_2$

Benzopiperidine, $C_{34}H_{15}NO_2$.—When chloride of benzoyl is made to act on piperidine, a large quantity of heat is evolved, and hydrochlorate of piperidine is formed, together with an oily, heavy liquid, which may be easily freed from the hydrochlorate by washing with acidulated water. When left to itself, it soon solidifies; and when the solid mass is dissolved in alcohol, which dissolves it readily, and the solution evaporated, the new compound separates in the form of beautiful colourless prisms analogous to benzamide.

	Calculation.	Mean Experiments.
24 C . . . 144	76 18	75·90
15 H . . . 15	7·94	8·11
N . . . 14	7·41	7·57
2 O . . . 16	8·47	—
C ₂₄ H ₁₅ NO ₂ . . 189	100·00	

The formation of this compound may be represented by the equation:



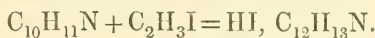
Cumyloperidine, $C_{30}H_{11}NO_2$.—Obtained in a similar manner by the action of chloride of cumyl on piperidine.

Chloride of acetyl appears also to exert a similar action.

Sulphocarbonate of Piperidine, $C_{10}H_{11}N, CS_2$.—When bisulphide of carbon is added drop by drop to piperidine, a very rapid action takes place, and the mixture becomes very hot. No gas is however disengaged, neither is the slightest formation of sulphuretted hydrogen perceptible. The liquids must be mixed cautiously, otherwise a portion of the contents of the vessel will be thrown out. If, when the action is terminated (the sulphide of carbon having been used in excess), the solid mass be taken up by alcohol, which dissolves it readily, especially when hot, and the solution left to evaporate, the compound separates, sometimes in fine needles, sometimes in crystals of considerable size, having the form of a symmetrical oblique prism.

		Calculation.	Experiment.
11 C	. . .	66	53·65
11 H	. . .	11	8·94
N	. . .	14	11·38
2 S	. . .	32	26·03
C ₁₀ H ₁₁ N, CS ₂		123	100·00

Methyloperidine, $C_{12}H_{13}N$.—Formed by the action of iodide of methyl on piperidine. The iodide of methyl must be added drop by drop, and the tube cooled while the mixing is going on; otherwise, a portion of the contents will be thrown out. If the liquids are mixed in equal volumes, there is formed a beautiful white crystalline mass, which is soluble in water, and when treated with potash, yields an oily liquid, also soluble in water; this oily liquid has an ammoniacal odour like that of piperidine, but more aromatic. After being digested with fragments of caustic potash, and then rectified, the new product assumes the form of a colourless, very mobile liquid, having an ammoniacal and aromatic odour, soluble in water, boiling at $118^{\circ}C$, and forming crystallizable compounds with acids. This compound is methyloperidine, its formation is expressed by the equation:



				Calculation.	Experiments.
12 C	.	.	72	72.72	72.83
13 H	.	.	13	13.13	13.74
N	.	.	14	14.15	14.35
$C_{12}H_{13}N$			99	100.00	100.42

The vapour-density is found by experiment to be 3.544; and supposing that the preceding formula represents 4 volumes of vapour, the calculated density is 3.513.

Methyloperidine forms with hydrochloric acid, a salt which crystallizes in beautiful colourless needles. The solution of this salt forms with bichloride of platinum, a compound soluble in water and more soluble in alcohol; when the alcoholic solution is left to evaporate, the salt separates, sometimes in needles, sometimes in tables of a fine orange colour. The formula of this salt is $C_{12}H_{13}N, HCl, PtCl_2$.

Methyloperidine, in contact with iodide of methyl becomes slightly heated, and the mixture, if heated in a sealed tube, finally solidifies. On dissolving the product in alcohol and leaving the solution to evaporate, magnificent crystals are obtained, which become very brilliant after being dried on bibulous paper. These crystals, when distilled, partly volatilize and are partly decomposed into methyloperidine and iodide of methyl.

14 C	.	.	84	35.00	34.90
16 H	.	.	16	6.67	6.75
N	.	.	14	5.83	5.92
I	.	.	126	52.50	—
$C_{14}H_{16}N, I$	.		240	100.00	

Ethyloperidine, $C_{14}H_{15}N$.—Piperidine becomes strongly heated by contact with iodide of ethyl, but not so much as with iodide of

methyl. The mixture, heated in sealed tubes in the water-bath, solidifies into a mass of fine white crystals, which, when decomposed by potash, yield an oil, the odour of which resembles that of piperidine, but is less ammoniacal and more aromatic. This liquid, which is colourless, and very mobile, boils at 128° . Its density is less than that of water. It is soluble in water, but less so than piperidine. Pieces of potash added to the solution effect the complete separation of the base. Alcohol and ether dissolve it readily.

		Calculation.	Mean Experiment.
14 C	. . . 84	74.33	74.16
15 H	. . . 15	13.27	13.19
N	. . . 14	12.40	12.59
$C_{14}H_{15}N$	. . . 113	100.00	

The vapour-density is by experiment, 3.986; by calculation, supposing the formula to represent 4 vols. of vapour, 3.959.

The *hydrochlorate of ethyloperidine* crystallizes in beautiful needles, possessing considerable lustre. Their formula is $C_{14}H_{15}N$, HCl.

When a concentrated solution of this salt is mixed with a concentrated solution of bichloride of platinum, a copious precipitate is formed, which dissolves in a larger quantity of water, especially if hot. If it be redissolved in a mixture of equal parts of water and alcohol, and the solution left to evaporate, the salt separates in large, beautiful, orange-coloured prisms.

Ethyloperidine scarcely becomes heated by contact with iodide of ethyl. When the liquids are enclosed in a sealed tube, the iodide of ethyl in excess, and heated for several hours in the water-bath, a viscid mass is obtained, which floats upon the hydriodic ether. Water dissolves it readily, and in all proportions; the solution does not crystallize *in vacuo*. When it is treated with oxide of silver recently precipitated and washed, a deposit of iodide of silver is obtained, and a liquid which, when evaporated *in vacuo*, yields very deliquescent crystals, having a bitter taste and a strong alkaline reaction. These crystals, when strongly heated, decompose, giving off an inflammable gas and ethyloperidine; they dissolve in hydrochloric acid, with evolution of heat. The liquid being concentrated by heat, or better, by evaporation *in vacuo*, yields a very deliquescent salt, which crystallizes in scales. The solution of the hydrochlorate forms a copious precipitate in a strong solution of bichloride of platinum. If very dilute and boiling solutions be used, the mixture on cooling deposits orange-coloured crystals, very much like those of chloroplatinate of potassium. The composition of this platinum-salt is as follows:

	Calculation.		Experiment.
18 C . . .	108	31·17	31·01
20 H . . .	20	5·76	5·82
3 Cl . . .	106·5	30·73	
N . . .	14·0	4·06	
Pt . . .	98·0	28·28	28·26
$C_{18}H_{19}N, HCl, PtCl^2$.	246·5	100·00	

Amylopiiperidine, $C_{20}H_{21}N$.—Iodide of amyl scarcely becomes heated by contact with piperidine; but the mixture soon solidifies when heated in the water-bath in sealed tubes. If, after the action has gone on for several days, the crystals be dissolved in a small quantity of water and the liquid distilled in contact with fragments of caustic potash, a limpid liquid passes over, having both an ammoniacal and an amylic odour. This compound, after being dried by fused caustic potash, and then redistilled, forms a colourless liquid, which boils at 186° , but is less soluble in water than the corresponding ethyl and methyl compounds. It forms crystallizable salts with acids.

	Calculation.		Experiment.
20 C . . .	120	77·41	77·54
21 H . . .	21	13·55	13·64
N . . .	14	9·04	9·17
$C_{20}H_{21}N$. .	155	100·00	

The vapour-density is by experiment 5·477; by calculation, supposing the equivalent to represent 4 vols. of vapour, it is 5·452.

Hydriodate of amylopiiperidine forms large, white, shining laminae.

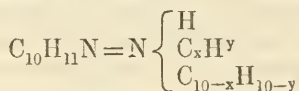
When a solution of bichloride of platinum is poured into a hot solution of hydrochlorate of amylopiiperidine, dark, orange-coloured, oily drops are deposited, which solidify in a few hours, presenting a crystalline aspect. On dissolving this product in dilute alcohol, and evaporating slowly, the platinum-salt separates in very hard prisms, often of considerable size, and of a fine orange colour, even when the quantity of material operated upon is small. The formula of the salt is $C_{20}H_{21}N, HCl, PtCl_2$.

The reactions of piperidine above described might lead to the supposition that it is a base belonging to the amylene series, and formed from amylene, $C_{10}H_{10}$, by the substitution of NH_2 for H , or as a compound ammonia formed by the substitution of the radical $C_{10}H_9$ for one of the atoms of hydrogen; according to the latter

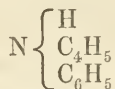
supposition, its rational formula would be $\left. \begin{matrix} C_{10}H_9 \\ H \\ H \end{matrix} \right\} N$. This view of its composition would agree very well with the results obtained by

treating it with the iodide of methyl and ethyl. To test the truth of this hypothesis, M. Cahours examined the action of bromide of amylene, $C_{10}H_{10}Br_2$, on an alcoholic solution of ammonia. The two liquids mix easily at ordinary temperatures, without producing any particular result; and even when they were heated together in a sealed tube for several days, the only products obtained were hydrobromate of ammonia and the compound $C_{10}H_9Br$, together with a very small quantity of an oily liquid having an ammoniacal odour; neither was any particular action produced by treating an alcoholic solution of ammonia with the compound $C_{10}H_9Br$, or with the corresponding compounds C_4H_3Br , C_6H_5Br , C_8H_7Br .

From these negative results it would appear that the radical $C_{10}H_9$, and the analogous compounds C_4H_3 , C_6H_3 , &c., are not capable of replacing either of the atoms of hydrogen in ammonia. The author is therefore disposed to regard piperidine as an imidogen-base, resulting from the substitution of two binary molecular groups for 2 atoms of hydrogen in ammonia; according to this view, its formula may be written as follows:



The author's experiments have not yet enabled him to determine the values of x and y ; but the composition of the base is perhaps that which is represented by the formula,



the hydrogen being replaced partly by ethyl, partly by allyl; this however is at present a pure hypothesis, not founded on any experiment. The general properties and basic power of piperidine show that it occupies an intermediate place between aniline and Wurtz's ammoniacal bases, approaching, however, more nearly to the former. From picoline, with which Rochleder and Wertheim had compared it, it differs in every respect.

Researches on the Oxygen-Radicals.

By L. Chiozza.*

The recent investigations of Gerhardt on the anhydrous monobasic acids,† have clearly shown that these acids contain, in a duplicate form, those oxygenated groups of atoms which are contained as one atom in the ordinary hydrated acids.

* Ann. Chem. LXXXIV, 102; Comp. rend. XXXV, 225.

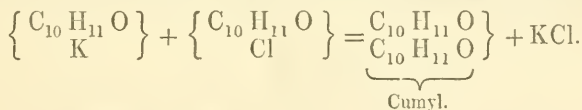
† Chem. Soc. Qu. J. V, 127, 226.

The process by which benzoic benzoate, cuminic cuminate, &c., were prepared, naturally leads to the expectation that the radicals themselves may be obtained by causing the chlorides of these oxygenated groups of atoms to act on the metallic compounds derived from the corresponding aldehydes. This expectation is fully confirmed by the following experiments.

When cuminol is heated with potassium in a small, covered platinum crucible, a product is obtained having the composition $C_{10}H_{11}O$.* It may be purified from undecomposed cuminol by pressure between filtering-paper, and subsequent exposure over oil of vitriol *in vacuo*.

The substance thus obtained, when brought in contact with an equivalent quantity of chloride of cumyl, soon becomes liquid, and forms a homogeneous mixture, which, when the temperature is slightly raised, becomes pasty from separation of chloride of potassium. The mass is then to be treated, first with water, then with a solution of carbonate of potash, and finally shaken up with ether. A stratum of ether, containing the whole of the cumyl, soon rises to the surface of the liquid; it is removed by a pipette, and the ether driven off by a gentle heat. To free the product completely from the water which it contains, it must however be heated till it begins to give off vapours.

The action which takes place between the compound $C_{10}H_{11}KO$ and the chloride of cumyl, is expressed by the following equation:



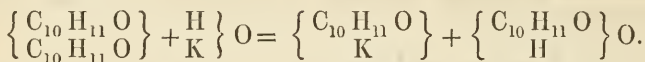
Cumyl presents the appearance of a thick oil, heavier than water. At ordinary temperatures its odour is faint, but when gently heated, it gives off an agreeable odour like that of geraniums. In this respect it resembles benzoyl, $\left. \begin{array}{c} C_7H_5O \\ C_7H_5O \end{array} \right\}$ the compound which Ettling and Stenhouse obtained by the dry distillation of benzoate of copper.

Cumyl is difficult to inflame, and burns with a smoky flame. In a mixture of ice and salt, it solidifies, forming a colourless, amorphous mass. On being again raised to the ordinary temperature of the air, it recovers its fluidity. It dissolves with tolerable facility in boiling alcohol, but very sparingly in cold alcohol. Cumyl boils at a temperature above 300° , decomposing at the same time into cuminic acid and other less oxygenated products, while a carbonaceous residue remains in the retort.

Cumyl gives by analysis numbers corresponding to the formula, $C_{20}H_{22}O_2$.

* Gerhardt's Notation. See papers last cited.

When cumyl is heated with a small quantity of hydrate of potash, cuminate of potash is formed, and the strong, characteristic odour of cumal is evolved.



The author endeavoured by similar means to form cumyl-benzoyl, $\left\{ \begin{array}{c} \text{C}_{10} \text{H}_{11} \text{O} \\ \text{C}_7 \text{H}_5 \text{O} \end{array} \right\}$ and cumyl-acetyl (or cumyl-othyl) $\left\{ \begin{array}{c} \text{C}_{10} \text{H}_{11} \text{O} \\ \text{C}_2 \text{H}_3 \text{O} \end{array} \right\}$; but the experiments have not yet led to any satisfactory result.

On Anhydrous Organic Acids.

By L. Chiozza.*

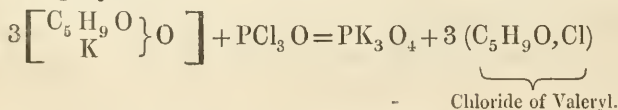
Valerianic Acid.—When valerianate of potash, purified by evaporating its alcoholic solution to dryness, and heating the residue till it begins to melt, is brought in contact with oxychloride of phosphorus, a violent action immediately takes place; the insupportable odour of the oxychloride is destroyed, and the mixture is converted into a saline mass, saturated with a viscid, faintly-smelling oil. The latter substance is *Valerianic Valerianate*, or *Anhydrous Valerianic Acid*. To obtain it pure, it must be treated, first with a very dilute solution of carbonate of potash, then with ether, and the ethereal solution, after being shaken up with chloride of calcium, left to evaporate over the water-bath.

The substance, thus purified, gave by analysis numbers agreeing exactly with the formula $\text{C}_{10} \text{H}_{18} \text{O}_3$.

Anhydrous valerianic acid is a colourless, tolerably mobile oil, lighter than water. When recently prepared, it has a faint, and by no means unpleasant odour, like that of apples; but if rubbed on the hands, it imparts to them the odour of valerianic acid, which lasts for several days. The vapour attacks the eyes, and excites coughing. Boiling water slowly converts the oil into hydrated valerianic acid. The same transformation is quickly effected by alkaline solutions, and instantly by fused potash.

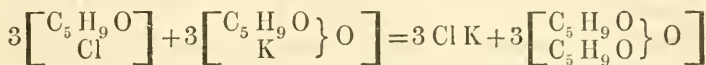
The anhydrous acid boils at 215° , distilling over in the form of a colourless liquid like water.

The formation of anhydrous valerianic acid is explained as follows: Oxychloride of phosphorus converts a portion of the valerianate of potash into phosphate of potash and *chloride of valeryl*, as shown in the following equation:



* Ann. Ch. Pharm. LXXXIV, 106; LXXXV, 229.

But the chloride of valeryl acts in its turn on the valerianate of potash, in such a manner, that the final products of the reaction are phosphate of potash, chloride of potassium, and anhydrous valerianic acid.



Benzoic Valerianate, or Valerianic Benzoate, $\begin{array}{c} \text{C}_5 \text{H}_9 \text{O} \\ \text{C}_7 \text{H}_5 \text{O} \end{array} \text{O}$. — This compound is readily obtained by the action of chloride of benzoyl on valerianate of potash. It is an oil, heavier than water, neutral to test-paper, and having an odour very much like that of valerianic acid. Its vapour is pungent, and excites tears. Alkaline liquids convert the oil into benzoate and valerianate of the alkali.

Benzoic valerianate is resolved by distillation into anhydrous benzoic and anhydrous valerianic acid. This decomposition does not, however, take place so quickly as that of benzoic acetate;* and to obtain the anhydrous valerianic acid, it is necessary to rectify the product several times.

The property which anhydrous acids possess of forming amides or anilides, when they act on ammoniacal gas or on aniline, furnished the author with the means of preparing a new compound, viz.:

Valeraniide.—This compound is in fact produced when anhydrous valerianic acid is brought in contact with aniline. It crystallizes in splendid, elongated, rectangular laminae, which have a strong lustre, and fuse at 115° . It is slightly soluble in boiling water, in which also it melts into clear drops. At a temperature above 220° , it distils over for the most part unchanged. Alcohol and ether dissolve it readily. A concentrated and boiling solution of caustic potash acts on it very slowly; fused hydrate of potash causes a perceptible evolution of aniline.

The crystallization of this compound exhibits a remarkable circumstance, already observed by Gerhardt in the crystallization of formanilide. When valeraniide separates from its solution in boiling dilute alcohol, it often takes the form of oily drops, which remain permanent for several hours, even after the liquid has become perfectly cold; but on a slight movement of the vessel, the whole mass solidifies almost instantly to a group of fine needles.

The analysis of valeraniide yields numbers which agree perfectly with the formula, $\text{C}_{11} \text{H}_{15} \text{NO}$.

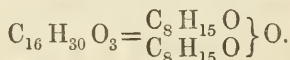
Anhydrous Caprylic Acid.—Hydrated caprylic acid was prepared by Fehling's method from cocoa-nut-oil, and separated from the caproic acid which accompanied it, by neutralizing with caustic

* Chem. Soc. Qu. J. V, 225.

baryta, and purifying the caprylate of baryta, which crystallizes out first, by several recrystallizations.

This baryta-salt is very easily attacked by oxychloride of phosphorus, the action being attended with but a slight elevation of temperature, and the mixture changing to a pasty mass, from which the anhydrous caprylic acid may be easily separated by ether free from alcohol. The ethereal solution is then treated with weak potash, then dried over chloride of calcium, and the ether driven off by the heat of the water-bath.

Anhydrous caprylic acid (caprylic caprylate), thus obtained, gave by analysis numbers agreeing perfectly with the formula,



It is a colourless, very mobile oil, greasy to the touch, and lighter than water. Its odour is repulsive. When heated, it gives off vapours which irritate the throat strongly, and have an odour more aromatic than that of the oil. In a mixture of ice and salt, it solidifies to a white mass, which appears crystalline only when examined by the microscope. At a few degrees below 0° , it recovers its fluidity. Boiling-point about 280° , but rising towards the end of the distillation to 290° , the residue in the retort at the same time assuming a darker colour, and giving off empyreumatic, disagreeably smelling products.

When anhydrous caprylic acid is brought into contact with aniline, the mixture becomes slightly heated, and in a few days solidifies to a buttery mass. It is probable that the product of this action is *Caprylanilide*, or at least that this substance is one of the products formed thereby; but the tendency of the mass to retain the liquid state renders it very difficult to obtain a pure product.

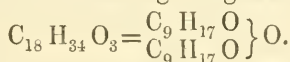
Boiling water has no action on anhydrous caprylic acid. This substance may indeed be distilled with water, without exhaling any odour of hydrated caprylic acid; it is, however, partially converted into the hydrate by long exposure to the air. Moderately strong potash-ley converts it, when warmed, into caprylate of potash.

We see then that, whereas anhydrous acetic acid is converted into the hydrated acid by mere contact with water, and anhydrous valerianic acid quickly absorbs water when simply exposed to moist air, caprylic acid, which is a higher member of this group of homologous acids, shows so little tendency to unite with water, that the intervention of caustic alkalis is necessary to convert it into the hydrate. Anhydrous pelargonic acid exhibits this resistance to reagents in a still higher degree.

Anhydrous Pelargonic Acid.—Prepared in a similar manner to the compound last described. Colourless oil, lighter than water.

In the cold, its odour is faint, like that of rancid butter; but when put into boiling water it imparts to the watery vapour an aromatic, slightly vinous odour, which is not at all unpleasant. Heated by itself upon glass, it emits pungent vapours, which smell like burnt fat.

At 0° C. it solidifies in a mass of fine needles, which melt again at 5°. Its analysis gave numbers agreeing exactly with the formula,



Benzoic Pelargonate, or *Pelargonic Benzoate*, $\text{C}_{16} \text{H}_{22} \text{O}_3 = \left. \begin{matrix} \text{C}_7 \text{H}_5 \text{O} \\ \text{C}_9 \text{H}_{17} \text{O} \end{matrix} \right\} \text{O}$.—Colourless oil, heavier than water, and closely resembling anhydrous pelargonic acid in its physical properties. At a few degrees below 0° C. it changes to a buttery mass, which immediately resumes its liquid form when taken out of the freezing mixture. When heated, it gives off highly pungent vapours, and decomposes at a high temperature, yielding anhydrous benzoic and anhydrous pelargonic acid, accompanied by a few other products resulting from the decomposition of the latter. The change which this substance undergoes, when heated, may be understood by exposing it to the action of cold; there is then formed a crystalline precipitate, which does not redissolve till the mixture is stirred.

A drop of benzoic pelargonate, when left to itself in moist air, yields delicate crystals of benzoic acid. With alkalis, benzoic pelargonate yields a benzoate and a pelargonate.

On Sinapine.*

By MM. Babo and Hirschbrunn.

The process employed by the authors for separating sinapine from mustard is as follows: A considerable quantity, at least 25 lbs., of mustard (Dijon mustard), is compressed to extract the oil, and the residue exhausted successively, by cold alcohol and hot alcohol of 85 per cent. The alcoholic liquors are mixed together, and distilled to about three-fourths, till a portion of the residue separates on cooling into two equal layers, the upper of which is an oil, and the lower an alcoholic solution of sulphocyanide of sinapine.† Sometimes this lower stratum solidifies to a magma of crystals of sulphocyanide of sinapine; sometimes the crystallization may be brought about by the addition of small quantities of water; but in most cases a syrupy liquor is obtained, which only deposits the sulphocyanide of sinapine after careful evaporation.

* Ann. Ch. Pharm. LXXXIV, 10; Ann. Ch. Phys. [3] XXXVIII, 108.

† The substance which the authors call *sulphocyanide of sinapine* is that which is commonly regarded as *sinapine* itself (vid. p. 191.)

There is considerable difficulty in seizing the point at which the distillation ought to be stopped. If the concentration be not carried far enough, the oil which separates still contains alcohol and sinapine. In this case it is best to heat the oil gently, and add to it an alcoholic solution of sulphocyanide of potassium.

The sulphocyanide of sinapine crystallizes after a few days. The crystals are separated from the somewhat viscid mother-liquid by filtration through cloth and by pressure, and then dissolved in warm alcohol of 90 per cent. The solution, on cooling, yields crystals which are to be dissolved in boiling water; and the aqueous solution, after decolorization by animal charcoal, deposits on cooling yellowish, silky needles, united in tufts. These crystals, which resemble those of sulphate of quinine, dissolve slowly at ordinary temperatures, but readily with the aid of heat in alcohol and in water. The solutions have generally a yellowish tint, but become perfectly colourless on the addition of a drop of acid.

Sulphocyanide of sinapine, when pure and dry, may be heated to 130° without alteration. At this temperature it melts into a yellow liquid, which, on cooling, is transformed into a vitreous mass; at a higher temperature, it decomposes, giving off vapours which have a very unpleasant odour, and contain an alkaloid, probably methyamine. Its analysis gave the following results:

Calculation.		Experiment.		
		I.	II.	III.
34 C . . .	204	56.01	55.16	55.09
25 H . . .	25	6.77	6.88	6.75
2 N . . .	28	6.91	7.93	7.80
2 S . . .	32	8.81	9.13	
10 O . . .	80	21.69		
$C_{34}H_{25}N_2S_2O_{10}$	369	100.00		

These results differ considerably from those obtained by Henry and Garot.

Sulphocyanide of sinapine does not appear to combine directly with other bodies, but exhibits the following reactions:

Hot strong sulphuric acid dissolves it, blackening at the same time, and giving off hydrosulphocyanic acid. When a solution of sulphocyanide of sinapine in dilute sulphuric or in hydrochloric acid, is evaporated, hydrosulphocyanic acid is likewise evolved, and a liquid is obtained in which crystals form. Nitric acid instantly imparts to sulphocyanide of sinapine a deep red colour. On heating the liquid, the colour changes to yellow, and sulphuric acid may afterwards be detected in the solution.

Alkalies dissolve sulphocyanide of sinapine, forming a liquid of a deep yellow colour. This reaction is very delicate, and is produced

by most alkaline substances. On adding an acid to the alkaline solution, if not too dilute, the sulphocyanide of sinapine is reprecipitated. On the other hand, the solution is decomposed by boiling, and the addition of an acid gives rise to the formation of a crystalline compound, which constitutes a new substance. When the solution of sulphocyanide of sinapine is boiled with baryta-water, the liquid becomes decolorized, and a yellowish baryta-compound is separated, from which hydrochloric acid separates the crystalline compound just mentioned. The solution contains hydrosulphocyanic acid.

Under these circumstances, there is formed by the action of alkalis on sinapine, a weak acid, to which the authors give the name of *SINAPIC ACID*; it is prepared as follows:

Pure sulphocyanide of sinapine is dissolved in potash, and the solution, at a boiling-heat, supersaturated with hydrochloric acid. The resulting precipitate is purified by dissolving it several times in alcohol of 60 per cent. Sinapic acid is then obtained, crystallized in small prisms, slightly soluble in cold water and alcohol, more soluble in these liquids when hot, insoluble in ether. This acid combines with bases; the salts which it forms with the alkalis are crystallizable, but all, excepting the baryta-salt, are very unstable.

22 C . . .	132	58·93	58·67	58·92
12 H . . .	12	5·35	4·87	5·67
10 O . . .	80	35·72	36·46	35·41
C ₂₂ H ₁₂ O ₁₀ . . .	224	100·00	100·00	100 00

The formula of the baryta-salt is 2 BaO, C₂₂ H₁₀ O₈.

The solution of this substance in potash or soda changes very rapidly on exposure to the air, especially when it is neutral; it first becomes red, then green, and ultimately brown. Sinapate of potash forms white precipitates with chloride of calcium, chloride of barium, and alum; it precipitates and reduces the solutions of mercury, silver, and gold.

Heated to 150° or 200° C., it melts, and at a higher temperature decomposes, yielding an oil, which has not yet been analyzed. With nitric acid, it behaves like sulphocyanide of sinapine. In its composition and properties, it exhibits a close analogy with erythric acid, as described by Schunck and Stenhouse.

SINCALINE.—Sinapic acid is not the only product of the action of alkalis on sinapine; for there is likewise found an alkaloid, to which the authors give the name of *Sincaline*. It is isolated as follows:

A considerable quantity of sulphocyanide of sinapine is heated with baryta-water, till all the sinapic acid is deposited in the form of a baryta-salt. The solution, filtered and acidulated with sulphuric acid, is then mixed with a solution of protosulphate of iron and sulphate of copper. The sulphocyanide of copper, which precipitates, is then separated by filtration, the liquid treated with excess of

baryta-water to precipitate the oxides of iron and copper, and the excess of baryta separated by carbonic acid. The filtered solution, evaporated over the water-bath, yields a deliquescent crystalline mass of carbonate of sincaline.

To separate the alkaloid, the carbonate is converted into hydrochlorate, and the latter salt is decomposed by oxide of silver. By evaporating the filtered liquid, a colourless or slightly brown crystalline mass is obtained, which very rapidly absorbs moisture and carbonic acid from the air. This alkaloid, in many of its reactions, behaves like caustic potash. It precipitates all the metallic oxides, redissolving alumina and oxide of chromium when added in excess. It dissolves sulphur, forming a sulphide and a hyposulphite. It is not volatile, but is decomposed by dry distillation, giving off inflammable vapours, with an odour like that of methylamine.

Sincaline forms crystallizable but deliquescent compounds with hydrochloric, sulphuric, nitric, and carbonic acids. The authors have analyzed the double salts which hydrochlorate of sincaline forms with the chlorides of gold and platinum. These compounds are crystallizable, and composed as follows :

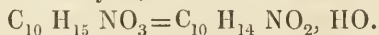
Double Hydrochlorate of Sincaline and Platinum.

Calculation.				Experiment.	
				I.	II.
10 C . . .	60.0	19.34		19.73	19.58
15 H . . .	15.0	4.83		5.16	5.10
N . . .	14.0	4.73			
2 O . . .	16.0	4.96			
3 Cl . . .	106.5	34.33			
Pt . . .	98.7	31.81		31.36	
		310.2	100.00		

Double Hydrochlorate of Sincaline and Gold.

Calculation.				Experiment.
10 C	60.0	13.50		13.63
15 H	15.0	3.38		3.38
N	14.0	3.15		
2 O	16.0	3.61		
3 Cl	106.5	32.02		
Au	199.0	44.34		44.54
		410.5	100.00	

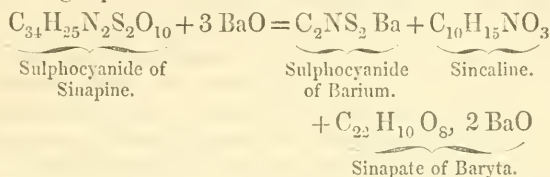
According to these analyses, sincaline contains :



It is, therefore, an oxygenated alkaloid, and, from a general view of its properties, may be regarded as belonging to the fourth class of

the alkaloids discovered by Hofmann, differing from these, however, in one circumstance—viz., that its gold- and platinum-salts contain oxygen.

SINAPINE.—The composition of sinapic acid and of sincaline affords a satisfactory explanation of the decomposition of sulphocyanide of sinapine by baryta-water. This decomposition is, in fact, expressed by the following equation :



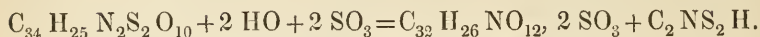
It still, however, remains to be determined whether this body is to be regarded as the sinapate of a copulated base composed of sincaline and hydrosulphocyanic acid, like Fritzsche's cyanharmaline or Hofmann's cyaniline, or as the sulphocyanogen-compound of an alkaloid containing the elements of sincaline and sinapic acid. For the decision of this question, it is of great importance to know that there exist two modifications of sulphocyanide of sinapine, one of which reddens ferric salts immediately, like every other sulphocyanide, while the other does not produce that effect without the aid of heat. This circumstance explains the discrepancy existing in the statements of different authors respecting the so-called sinapine, some asserting that it reddens iron-salts, while others say that it does not.

The following reaction appears to throw still further light upon this question.

When a small quantity of strong sulphuric acid is added to a hot concentrated solution of sulphocyanide of sinapine in alcohol of 90 per cent, the liquid deposits, on cooling, a quantity of rectangular laminae, which completely fill it. These crystals consist of the acid sulphate of a new alkaloid, to which the authors give the name of *Sinapine*, regarding it as the base of the sulphocyanide of sinapine. By filtration and washing with absolute alcohol, these crystals may be separated from the mother-liquor, which contains hydrosulphocyanic acid. Dried at 100°, they contain $\text{C}_{32}\text{H}_{26}\text{NO}_{12}$, 2SO_3 , as shown by the following analysis :

		Calculation.	Experiment.
32 C	192	47·06	46·99
26 H	26	6·37	6·37
N	14	3·43	—
12 O	96	23·53	—
2 SO ₃	80	19·61	19·82
C ₃₂ H ₂₆ NO ₁₂ , 2 SO ₃		408	100·00

The formation of this salt is represented by the following equation :



In the crystallized state, this acid salt likewise contains 4 atoms of water of crystallization, which it gives off at 110° . It has a strongly acid reaction, and dissolves readily in water and in boiling alcohol, from which it separates again on cooling.

All attempts to isolate the base in the solid state failed, in consequence of the facility with which it separates into sinapic acid and sincaline. But on adding baryta-water to a solution of the acid sulphate of sinapine, sulphate of baryta is precipitated, and the remaining solution, when freed from excess of baryta by careful addition of sulphuric acid, forms an intensely yellow liquid, having a distinctly alkaline reaction, and capable of precipitating many metallic oxides from their solutions. The solution, when evaporated, turns first green and then red, and leaves a non-crystalline residue, from which no definite compound is extracted, either by alcohol or by ether. When the solution of the acid sulphate is boiled with oxide of lead, the sinapine appears to form a compound with this base. On boiling the same solution with excess of potash or baryta, the sinapine is immediately resolved into sinapic acid and sincaline.

The salts of sinapine are colourless, and more stable than the base itself. The neutral sulphate is obtained by neutralizing the second equivalent of sulphuric acid in the acid sulphate with baryta-water, then filtering and evaporating. It forms a very soluble crystalline mass, from the solution of which the hydrochlorate or nitrate may be formed by careful addition of chloride of barium or nitrate of baryta. Both these salts crystallize in delicate, very soluble needles. On heating either of these salts with a solution of sulphocyanide of potassium, sulphocyanide of sinapine is reproduced, and crystallizes on cooling, exhibiting all the properties of the original substance.

From all these facts, we may conclude that the substance extracted from mustard is the sulphocyanide of a copulated base, the true *sinapine*, which is very unstable, and separates with the greatest facility into sinapic acid and sincaline.

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

XVII.—*On the Amides.*

BY C. GERHARDT.

(FROM A LETTER TO DR. WILLIAMSON.)

In my paper on the anhydrous acids, I have advanced the opinion that the majority of organic compounds hitherto well known may be derived from a very small number of types, belonging to mineral chemistry—such, for instance, as water, hydrochloric acid, ammonia, &c. Considered as terms of a series, the bodies derived from each of these types have not identical properties; their properties are, in fact, progressive, the difference between them increasing with the interval between the places in the series which they occupy. According to this view, we may comprehend under *one type*, acids, bases, and neutral bodies, the acids being placed at one end of the series, the bases at the other, and the neutral bodies which form the transition between the two extremes occupying the middle place. If, for the sake of simplification, we designate the two extremes by the words positive and negative, we may say that there are groups, or organic radicals, such as methyl, ethyl, phenyl, which being substituted for the hydrogen of the preceding types, produce *positive derivatives*—that is to say, bodies more or less resembling bases; whilst other groups or radicals, such as othyl* (or *acetyl*), benzoyl, cumyl, give rise, by a similar substitution, to *negative derivatives*, or bodies more or less

* The term "othyl" has been substituted for "acetyl" at the suggestion of Dr. Williamson, to avoid confusion between the oxygen-radical C_2H_3O and the hydrocarbon C_2H_5 , to which the name of "acetyl" has long been applied.

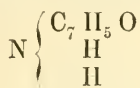
analogous to acids. This point appears to me to be now completely established with regard to the derivatives of the water or oxide type, including the alcohols, ethers, hydrated acids and anhydrous acids; and it is no less evident in the derivatives of the hydrochloric acid type, comprising the chlorides which correspond to these different organic oxides.

With respect to the derivatives of the ammonia type, chemists, doubtless relying on the constancy of chemical characters exhibited by the derivatives of the same type, have regarded ammonia as the type of those bodies only which have strongly marked alkaline properties. In this point of view, the beautiful researches of Dr. Hofmann on the organic bases have enriched science with a considerable number of compounds. But these occupy only one extremity of the series—that is to say, the positive extremity, already occupied by alcohol and ether, or in general by those organic oxides which are similar to bases, and contain the same radicals as the alkaline ammonias themselves. But if, as I suppose, the properties of the derivatives of the same type, instead of being constant, vary in regular series, then there must also exist ammonias occupying the negative extremity of the series, together with the hydrated and anhydrous acids; in other words, the same groups or radicals which, by substitution for 1 or 2 atoms of hydrogen in water, give rise to hydrated or anhydrous acids, must also be able to take the place of 1, 2 or 3 atoms of hydrogen in ammonia, and thus produce neutral ammonias, and ammonias more or less acid. From this point of view, the already known amides of monobasic acids may, I think, be regarded as realizing the substitution of the first atom of hydrogen in ammonia by an acidifying group (benzoyl, othyl, cumyl); we know, in fact, that these amides are feeble acids, in which an atom of hydrogen may be replaced by mercury, silver, &c. But to complete the demonstration, it still remains to effect the same substitutions on the other 2 atoms of hydrogen in ammonia. This is, in fact, what M. Chiozza and myself have endeavoured to do, by the experiments which I proceed to describe.

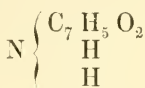
At the commencement of this research an important point demanded our attention—namely, the preparation of the amides required for our experiments—preparations often lengthy and tedious when carried on by the usual processes. These we replace by a very simple and expeditious method, which consists in treating the solid commercial carbonate of ammonia directly with the chloride corresponding to the acid whose amide we wish to obtain. The action is immediate, carbonic acid is disengaged, and a simple washing with cold water dissolves

the chloride of ammonium formed in the reaction. In this manner, large quantities of benzamide, cuminamide, sulphophenylamide,* &c., may be obtained with the greatest ease. The negative chlorides required for these preparations are obtained by means of the perchloride or oxychloride of phosphorus. In place of the chlorides, the corresponding anhydrous acids may be used.

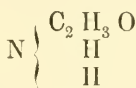
The amides thus produced, which we shall call *primary amides*, represent a molecule of ammonia in which 1 atom of hydrogen is replaced by the negative radicals, benzoyl, cumyl, othyl, salicyl, sulphophenyl, &c.



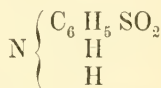
Benzoylamide.



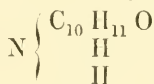
Salicylamide.



Othylamide.



Sulphophenylamide.



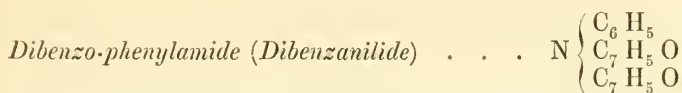
Cumylamide.

To convert the preceding compounds into *secondary amides*, or amides representing a molecule of ammonia in which 2 atoms of hydrogen are replaced by the negative radicals, we heat these primary amides with an equivalent quantity of chloride of benzoyl, of cumyl, sulphophenyl, &c. Abundant fumes of hydrochloric acid are disengaged, and a residue is left consisting of the secondary amide. These operations must be conducted at a determinate temperature; for some primary amides, when heated too strongly, spontaneously suffer a secondary decomposition, resulting in the formation of nitriles (cyanides of the alcohol-radicals). This secondary decomposition often interferes considerably with the results of these experiments, and renders their execution much more difficult than would at first be supposed. The secondary amides may likewise be produced, in certain cases, by the action of the anhydrous acids on the primary amides.

With regard to the *tertiary amides*, representing a molecule of ammonia in which the 3 atoms of hydrogen are replaced by negative groups, their preparation is generally easier than that of the secondary amides; for these, having much more strongly marked acid properties than the primary amides, form metallic salts more easily, and these are acted upon, even in the cold, by the chlorides of benzoyl, cumyl, &c.

It is then by double decomposition that we produce our new

* The amide of Mitscherlich's sulphobenzidic acid.



forms beautifully brilliant needles, slightly soluble in cold alcohol.

We are at present engaged in the study of the preceding bodies, and of many similar compounds. The number of the organic acids which form chlorides and anhydrous acids being very large, we may vary almost infinitely the substitutions by negative radicals, and thus form a vast number of new bodies. There is little doubt that many of the nitrogen-acids contained in plants exhibit a constitution similar to that of our new amides.

In a future communication I propose to speak of the *Diamides* (amides of bibasic acids), such as oxamide, of the *Acid Amides*, and the *Hydramides* (such as hydrobenzamide). The acid amides evidently correspond to the hydrated oxide of ammonium; they occupy one extremity of the series, at the other end of which are found the alkalies discovered by Dr. Hofmann (hydrated oxide of tetrethyl-ammonium), &c.

XVIII.—On an Improved Apparatus for the Analysis of Gases.

By DR. E. FRANKLAND, F.R.S. AND W. J. WARD, Esq.

Notwithstanding the acknowledged importance of the investigation of gaseous bodies, it is only within a comparatively recent period that this branch of chemical research has received that attention which it so well deserves.

When Bunsen, in the prosecution of his admirable researches on the gases evolved from the iron-furnaces of Germany,* attempted to apply to the analysis of those gases the best methods known at that time, he found himself compelled, by the great imperfections and inaccuracies of those methods, to re-investigate and remodel the whole subject of gaseous analysis. Commencing with the construction of the eudiometers themselves, and adopting the simple plan of graduation independent of volume, with subsequent calibration or determination of the actual value of each division of this independent graduation, he attained a degree of accuracy in the measurement of volumes which left nothing to be desired in this department. He then obviated the

* Pogg. Ann. Bd. XLVI, 193; L, 81, 673.

inaccuracies inseparable from the introduction of liquid solvents into the measuring-tubes, by the employment of those solvents or absorbents in the dry state, in the form of little bullets cast upon platinum or steel wires. Thus the inner walls of the eudiometers were preserved free from adhering impurity, whilst the convexity of the internal mercury was kept uniform. By further improvements in the absorbents employed, the determination of the limits of perfect combustion in the explosion of gases with oxygen and hydrogen, and many other important points connected with the true measurement of gaseous volumes, Bunsen brought this branch of chemical analysis to a state of perfection which, as shown by numerous researches made by himself, by Playfair, Kolbe, and others, left, so far as delicacy and perfect accuracy were concerned, scarcely either room or desire for further improvement.

It was however necessary, for the successful carrying out of these methods, that a room of tolerably constant temperature should be appropriated exclusively to this object, and that an interval of from half an hour to one hour should be allowed between each determination of volume in order that the gas in the eudiometer might perfectly assume the temperature of the circumambient air. These circumstances, though of little importance in the performance of occasional gas analyses, become serious considerations when a large number of such analyses have to be made consecutively, as the expenditure of time and space becomes in such cases very great.

For the removal of this difficulty we are indebted to Regnault, who, by enclosing the eudiometer in a cylinder filled with water, renders the equalization of the temperature of the gas and the external medium, the work of a few seconds only; thus greatly reducing the time occupied by an analysis, and obviating the necessity for an apartment exclusively appropriated to gaseous investigations. This chemist has also further facilitated the various operations upon gaseous mixtures, by a more convenient division of the apparatus into two parts, the one for absorption and the other for measurement, than that employed by Bunsen; as also by adopting the admirable method of always determining the gaseous volumes when saturated with aqueous vapour. Unfortunately, these great advantages are in some respects diminished by a somewhat less amount of delicacy in the manner of determining the volumes: M. Regnault maintains the volume of the gases during an analysis, constant, and measures the amount of pressure exercised by that constant volume, over or under the pressure of the atmosphere, expressed in millimetres of mercury. This method, though unexceptionable in principle, has yet the dis-

advantage in practice, that considerable changes of volume are represented by small numerical expressions when compared with those obtained by Bunsen's method. This is more especially the case with the first determination in an analysis, great delicacy in which is usually of much greater importance than in the subsequent readings.

To illustrate more clearly what we here mean, we give the determination of a small percentage of carbonic acid, contained in a small volume of gas, by the two methods :

BY BUNSEN'S METHOD.

	Absorbed volume.	Temp.	Difference of mercury level.	Height of barometer.	Corrected vol. at 0° C. and 1 ^m pressure.
Vol. of gas used (dry)	330.2	0° C.	550.4 ^{mm}	760.0 ^{mm}	69.20
Vol. after absorption of CO ₂ (dry) . .	327.8	0° „	549.6 „	760.1 „	69.00

BY REGNAULT'S METHOD.

	Observed pressure.	Temp.	Barometer.	Corrected pressure.
Gas used (moist) . .	—686.2	0° C.	760.0 ^{mm}	69.2
After absorption of CO ₂ (moist)	—686.5	0° „	760.1 „	69.0

Percentage of carbonic acid = 0.28.

Let us now suppose that an error of $\frac{1}{10}$ of a millimetre was made in the first observation in each of the above methods, and that thus the volume of gas used was read off according to Bunsen's method 330.1 vols., and according to Regnault's method—686.3. The percentage of carbonic acid by the two methods would then be as follows :

Carbonic acid per cent (Bunsen's method) . . .	0.260
„ „ „ (Regnault's method) . . .	0.145

Thus the error in the one case would amount to only .02 per cent, whilst in the other it would be nearly 7 times as great, and might even cause the carbonic acid to be entirely overlooked.

In endeavouring to remedy this defect, and at the same time to combine the advantages of the two methods, we proposed to ourselves the following qualifications as highly desirable in a good apparatus for the analysis of gases.

1. The determinations of the gaseous volumes should be made in a manner entirely independent of the pressure and temperature of the external atmosphere.

2. Such determinations of volume should also be self-correcting as

regards the tension of aqueous vapour and the variations in the density of mercury.

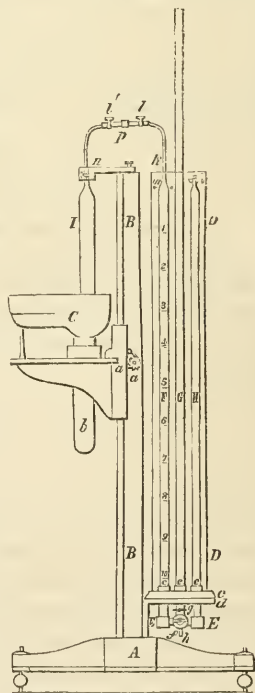
3. Each change of volume should be expressed by a numerical difference as large as possible.

4. In order to avoid the inconvenience and loss of time occasioned by tedious calculations, references to tables, &c., the numerical expression of each volume actually read off should either be the true and corrected volume, or a number from which such volume can be at once obtained by the most simple arithmetical process.

The advantage of securing the first and second of these qualifications is sufficiently obvious; for whilst we can then carry on the operations of gaseous analysis without an apartment of nearly constant temperature set apart for the purpose, the accuracy of our results is also not liable to be affected by any errors that may have been made in the determination of the expansion of gases by heat, the tension of aqueous vapour, and the expansion-coefficient of mercury. The third and fourth qualifications are also scarcely of inferior importance, the one for securing delicacy in the readings, and the other for economizing time and enabling the operator to see the corrected results of his experiments during their progress, an advantage which can be best appreciated by those who have had to make large numbers of consecutive gas analyses.

In constructing an apparatus to combine the foregoing qualifications, we have taken as a model the ingenious and very convenient arrangement of MM. Regnault and Reiset, with the mechanical arrangements of which, our apparatus, though different in principle, has much in common.

Our instrument, which is represented by the accompanying figure consists of the tripod *A* furnished with the usual levelling screws, and carrying the vertical pillar *B B*, to which is attached, on the one side, the moveable mercury-trough *C*,* with its rack and pinion *a a*, and on the other the glass cylinder *D D* with its contents. This cylinder is 36 inches long and



* The mercury-trough, including its tubular well *b*, may be conveniently constructed of gutta-percha.

4 inches internal diameter; its lower extremity is firmly cemented into an iron collar *c*, the under surface of which can be screwed perfectly water-tight upon the bracket-plate *d* by the interposition of a vulcanized caoutchouc ring. The circular iron plate *d* is perforated with three apertures, into which the caps *e e e* are screwed, and which communicate below the plate with the T-piece *E E*. This latter is furnished with a double-way cock *f* and a single-way cock *g*, by means of which the tubes cemented into the sockets *e e e* can be made to communicate with each other or with the exit-pipe *h* at pleasure.

F G H are three glass tubes, which are firmly cemented into the caps *e e e*. *F* and *H*, which are only slightly shorter than the glass cylinder, are each from 15^{mm} to 20^{mm} internal diameter, and are selected of as nearly the same bore as possible, to avoid a difference of capillary action. The tube *G* is somewhat wider, and may be continued to any convenient height above the cylinder. *H* is accurately graduated with a millimetre scale, and is furnished at top with a small funnel *i*, into the neck of which a glass stopper, about 2^{mm} in diameter, is carefully ground. The tube *F* terminates at its upper extremity in the capillary-tube *k*, which is carefully cemented into the small steel stop-cock *l*. *F* has also fused into it at *m* two platinum-wires for the passage of the electric spark. After this tube has been firmly cemented into the cap *e*, its internal volume is accurately divided into ten perfectly equal parts, which is effected without difficulty by first filling it with mercury from the supply-tube *G*, up to its junction with the capillary attachment, and then allowing the mercury to run off through the nozzle *h* until the highest point of its convex surface stands at the division 10, previously made so as exactly to coincide with the zero of the millimetre scale on *H*; the weight of the mercury thus run off is carefully determined, and the tube is again filled as before and divided into ten equal parts, by allowing the mercury to run off in successive tenths of the entire weight, and marking the height of the convexity after each abstraction of metal. By using the proper precautions with regard to temperature, &c., an exceedingly accurate calibration can, in this way, be accomplished.

The absorption-tube *I* is supported by the clamp *n*, and connected with the capillary-tube *k* by the stop-cock and junction-piece *l'p* in exactly the same manner as in Regnault's apparatus.

When the instrument is thus far complete, it is requisite to ascertain the height of each of the nine upper divisions on the tube above the lowest or tenth division. This is very accurately effected

in a few minutes by carefully levelling the instrument, filling the tube *G* with mercury, opening the cock *l* and the stoppered funnel *i*, and placing the cock *f* in such a position as to cause the tubes *F H* to communicate with the supply-tube *G*. On now slightly turning the cock *g*, the mercury will slowly rise in each of the tubes *F* and *H*; when its convex surface exactly coincides with the ninth division on *F*, the influx of metal is stopped, and its height in *H* accurately observed; as the tenth division on *F* corresponds with the zero of the scale upon *H*, it is obvious that the number thus read off is the height of the ninth division above that zero-point. A similar observation for each of the other divisions upon *F* completes the instrument.

Before using the apparatus, the large cylinder *DD* is filled with water, and the internal walls of the tubes *F* and *H* are once for all moistened with distilled water by the introduction of a few drops into each, through the stop-cock *l* and the stoppered funnel *i*. The three tubes being then placed in communication with each other, mercury is poured into *G* until it rises into the cup *i*, the stopper of which is then firmly closed. When the mercury begins to flow from *l*, that cock is also closed. The tubes *F* and *H* are now apparently filled with mercury, but a minute and imperceptible film of air still exists between the metal and glass; this is effectually got rid of by connecting *F* and *H* with the exit-tube *h* and allowing the mercury to flow out until a vacuum of several inches in length has been produced in both tubes; on allowing the instrument to remain thus for an hour, the whole of the film of air above mentioned will diffuse itself into the vacuum, and will become visible as a minute bubble in each tube on allowing the vacuum to be filled up from the supply-tube *G*. These bubbles are of course easily expelled on momentarily opening the cock *l* and the stopper *i* whilst *G* is full of mercury. The absorption-tube *I* being then filled with quicksilver, and attached to *l* by the screw clamp, the instrument is ready for use.

In localities where a constant supply of water from street mains can be had, the temperature of the water in the cylinder *DD* can be maintained perfectly constant by allowing a continuous stream, direct from the main, to flow into the bottom of the cylinder and make its exit near the top. By this arrangement, it has been proved by one of us, in an extensive series of experiments, that the temperature of a cylinder supplied from the Manchester high-pressure mains does not vary more than 0.02° C. in twelve hours, a variation which scarcely requires correction in the most delicate experiments.

In illustration of the manner of using our apparatus, we will take

as an example an analysis of atmospheric air. A few cubic inches of air freed from carbonic acid having been introduced into the tube *I*, it is transferred into *F* for measurement by opening the cocks *ll'* and placing the tube *F* in communication with the exit-pipe *h*; the transference can be assisted, if needful, by elevating the trough *C*. When the air, followed by a few drops of mercury, has passed completely into *F*, the cock *l* is shut, and *f* turned so as to connect *F* and *H* with *h*. Mercury is allowed to flow out until a vacuum of 2 or 3 inches in length is formed in *H*, and the metal in *F* is just below one of the divisions: the cock *f* is then reversed, and mercury very gradually admitted from *G* until the highest point in *F* exactly corresponds with one of the divisions upon that tube; we will assume it to be the sixth division. This adjustment of mercury and the subsequent readings can be very accurately made by means of a small horizontal telescope placed at a distance of about 6 feet from the cylinder, and sliding upon a vertical rod. The height of the mercury in *H* must now be accurately determined, and if from the number thus read off, the height of the sixth division above the zero of the scale on *H*, be deducted, the remainder will express the true volume of the gas; but in order to compare this with subsequent readings made at other divisions upon *F*, the number thus obtained, which evidently represents the pressure of the gas, is reduced to what it would have been had the gas been expanded to the tenth division of *F*. Bearing in mind that the pressure of a gas is inversely as its volume, this reduction is very simply effected by multiplying the number as above obtained by $\frac{6}{10}$, or 0·6; and in all cases, any determination of pressure made at any division upon *F* may be reduced to the pressure of the same volume when expanded to the tenth division, by the use of a fractional multiplier whose denominator is 10, and numerator the number of the division at which the determination is made.

As the temperature is maintained constant during the entire analysis, no correction on that score has to be made; the atmospheric pressure being altogether excluded from exerting any influence upon the volumes or pressures, no barometrical observations are requisite, and as the tension of aqueous vapour in *F* is exactly balanced by that in *H*, the instrument is in this respect self-correcting.

Hydrogen being then introduced in the same way as the original gas, and the volume determined anew, the electric spark is passed through the mixture by means of the platinum-wires at *m*, and the determination of the contraction caused by the explosion terminates the analysis. The following are the results of an analysis of air made in this way.

VOLUME OF AIR USED.

(Determined at fifth division on *F*.)

Observed height of mercury in <i>H</i> .	.	.	673·0 ^{mm}
Height of fifth division above zero	.	.	383·0
Corrected pressure of gas	.	.	= 290·0
			·5
Corrected pressure of gas at tenth division			= 145·00

VOLUME AFTER ADMISSION OF HYDROGEN.

(Determined at sixth division.)

Observed height of mercury in <i>H</i>	.	.	772·3 ^{mm}
Height of sixth division above zero	.	.	304·0
Corrected pressure of gas	.	.	= 468·3
			·6
Corrected pressure of gas at tenth division			= 280·98

VOLUME AFTER EXPLOSION.

(Determined at fifth division.)

Observed height of mercury in <i>H</i> .	.	.	763·3 ^{mm}
Height of fifth division above zero	.	.	383·0
Corrected pressure of gas	.	.	= 380·3
			·5
Corrected pressure of gas at tenth division			= 190·15

RESULTS.

Volume of air used	.	.	.	145·00
Volume of oxygen	.	.	.	30·276

Hence :

Nitrogen	.	.	.	79·120
Oxygen	.	.	.	20·880
100·000				

To show the delicacy of the indications of this instrument, we here subjoin the results of a series of analyses performed upon the same

specimen of atmospheric air, previously freed from carbonic acid by caustic potash.

	I.	II.	III.	IV.	V.	VI.
Oxygen	20·880	20·888	20·883	20·867	20·868	20·876
Nitrogen	79·120	79·112	79·117	79·133	79·132	79·124
	100·000	100·000	100·000	100·000	100·000	100·000

XIX.—*On the use of Hydrogen in determining Vapour-Densities, and on the Acidification of Alcohols by Oxygen-gas or Atmospheric Air.*

BY ROBERT RAILTON.

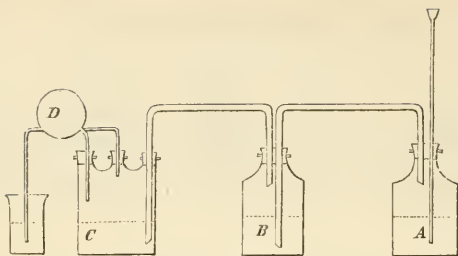
(OF UNIVERSITY COLLEGE.)

Whilst engaged in some experiments on the alcohol obtained by M. Bouis from castor-oil, which by combustion I had already found to agree with the formula $C_{14}H_{16}O_2$, I had occasion to ascertain the density of its vapour.

On determining it by the usual method, I found that the experimental density greatly exceeded the calculated density, and that the condensed vapour had an acid reaction, although the liquid which was introduced into the glass globe was perfectly neutral. The latter circumstance led me to suppose that the vapour of the alcohol combined, at a high temperature, with the oxygen of the air contained in the globe, forming an acid vapour which would necessarily be heavier than the alcoholic vapour; indeed it would appear from the density I obtained (4·535) that the œnanthylie alcohol was wholly converted by oxidation into the corresponding acid, $C_{14}H_{14}O_4$, the theoretical density of which is 4·531. Subsequent experiments confirmed the supposition.

To decide the matter completely, Dr. Williamson suggested to me to substitute dry hydrogen for common air in the globe; this method was tried, and led to the most satisfactory results. The experiment was conducted as follows:

The globe was first weighed, full of dry air, and the requisite amount of alcohol afterwards introduced; the air was then displaced by diffusion, an apparatus, of which the following is the sectional sketch, being used.



In the bottle *A* the hydrogen is generated, whence it passes into the wash-bottle *B*, and thence into the bottle *C*; the two latter bottles contain concentrated sulphuric acid, which is intended to dry the hydrogen thoroughly.

The globe or vapour-flask is fixed, with its long narrow neck downwards, into one of the necks of the bottle *C* by an air-tight cork, the orifice of the neck of the globe being above the sulphuric acid.

The third neck of the bottle *C* is closed by a cork, which is traversed by a bent tube of fine bore, in order that the hydrogen and air may escape under some pressure; and as a precaution against the possible return of moist air into *C*, the outer end of this tube dips into concentrated sulphuric acid.

The evolution of hydrogen is continued for two or three hours, during which time the air is gradually expelled from the globe: the rest of the operation is the same as in taking ordinary vapour-densities.

The following are the results of two experiments—the first, when the globe contained atmospheric air; the second, when the above-described method was adopted:

FIRST EXPERIMENT.

Capacity of the globe at 60° F.	27·70 cub. in.
Weight of globe filled with air at 58° F. and 30·12 in. bar.	866·58 grs.
Weight of globe filled with vapour at 531° F. and 30·12 in. bar.	878·17 „
Volume of residual air at 57° F. and 29·73 in. bar.	·55 cub. in.
27·70 cub. in. air at 58° F. and 30·12 in. bar. become at 60° F. and 30 in. bar. 27·92 cub. in., and weigh	8·66 grs.
Hence, weight of empty globe is	857·92 „

The capacity of the globe at 531° F.	27·87	cub. in.
Volume of residual air at 531° F.	1·06	„
Volume of vapour at 531° F. and 30·12 in. bar.	26·81	„
which at 60° F. and 30 in. bar. become	14·59	„
Weight of residual air	·17	grs.
„ empty globe	857·92	„
	858·09	„
Weight of globe and vapour	878·17	„
Weight of 14·59 cub. in. vapour at 60° F.	20·08	„
Weight of 100 cub. in. vapour	137·63	„
Whence the experimental density is	4·535	
Calculated density of the acid $C_{14}H_{14}O_4$	4·531	
Calculated density of the alcohol $C_{14}H_{16}O_2$	4·018	

SECOND EXPERIMENT.

Capacity of globe at 60° F.	24·50	cub. in.
Weight of globe filled with air at 56° F. and 29·65 in. bar.	1577·077	grs.
Weight of globe filled with vapour at 552° F. and 29·65 in. bar.	1584·876	„
Residual hydrogen at 60° F.	·20	cub. in.
24·50 cub. in. of air at 56° F. and 29·65 in. bar. become at 60° F. and 30 in. bar. 24·4 cub. in., and weigh	7·566	grs.
Hence, weight of empty globe	1569·511	„
Capacity of globe at 552° F.	24·67	cub. in.
Volume of residual hydrogen at 552° F.	·39	„
Volume of vapour at 552° F. and 29·65 in. bar.	24·28	„
which at 60° F. and 30 in. bar. become	12·323	„
Weight of residual hydrogen	·008	grs.
Weight of empty globe	1569·511	„
Weight of globe and vapour	1569·519	„
	1584·876	„

Weight of 12·323 cub. in. vapour at 60° F. 15·357 grs.

Weight of 100 cub. in. vapour 124·62 „

The experimental density is therefore 4·019

The theoretical density of the alcohol $C_{14}H_{16}O_2$ is 4·018

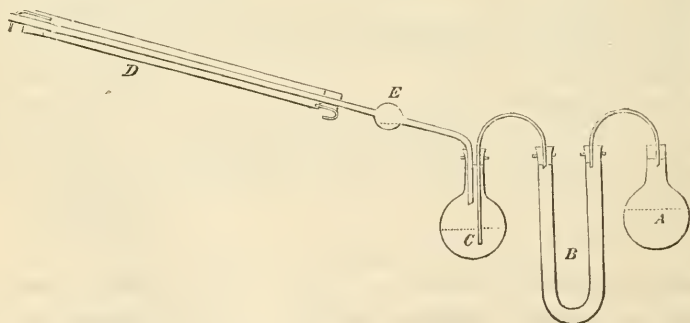
I may here remark that the condensed vapour in the last experiment was perfectly neutral.

These results suggested the idea that it was possible to convert the alcohol $C_{14}H_{16}O_2$ into the corresponding acid $C_{14}H_{14}O_4$ by simply passing a stream of dry oxygen or atmospheric air into the liquid while heat was being applied to it. To test this idea, an apparatus of the following construction was adopted :

A is a flask containing chlorate of potash and binocide of manganese. *B* is a tube containing chloride of calcium or other desiccating substance.

The alcohol to be oxidized is placed in the flask *C*. *D* is an arrangement of glass tubes forming a Liebig's condenser ; *E* is a bulb blown on the inner glass tube of the arrangement *D*.

The construction will be understood on referring to the figure, which is drawn in section.



The alcohol in the flask *C* is made to boil briskly ; at the same time, oxygen is supplied from *A* (or from a gas-holder) ; the oxygen enters at the bottom of the liquid. The vapour from *C* is condensed by the arrangement *D*, and continually flows back into *C*, until the whole is fully oxidized ; but as, during the process, water is formed, and as it would endanger the safety of the flask *C* if allowed to re-enter it, the bulb *E* is interposed, when the water, being of greater density, collects at the bottom of *E*, and the oily liquid alone returns to the flask *C*, there to undergo the same operation as before, until it is completely oxidized.

A considerable quantity of œnanthylic acid was obtained by this process, from which the baryta- and potash-salts were formed.

Fusel-oil was also oxidized in a similar manner, and doubtless the whole of the alcohols would yield their corresponding acids if subjected to the same treatment.

This subject was not further proceeded with, as my success in these experiments induced me to try others of contrary character, in which I am at present engaged. If they succeed—and there is some reason to believe they will—we shall have it in our power to produce artificially all the alcohols from their corresponding acids, by an extremely cheap and simple process. The deoxidation will be effected by hydrogen.

Whatever the results of my present experiments may be, as soon as they are completed, I shall have the honour of communicating them to the Society.

XX.—*On the use of Gas as Fuel in Organic Analysis.*

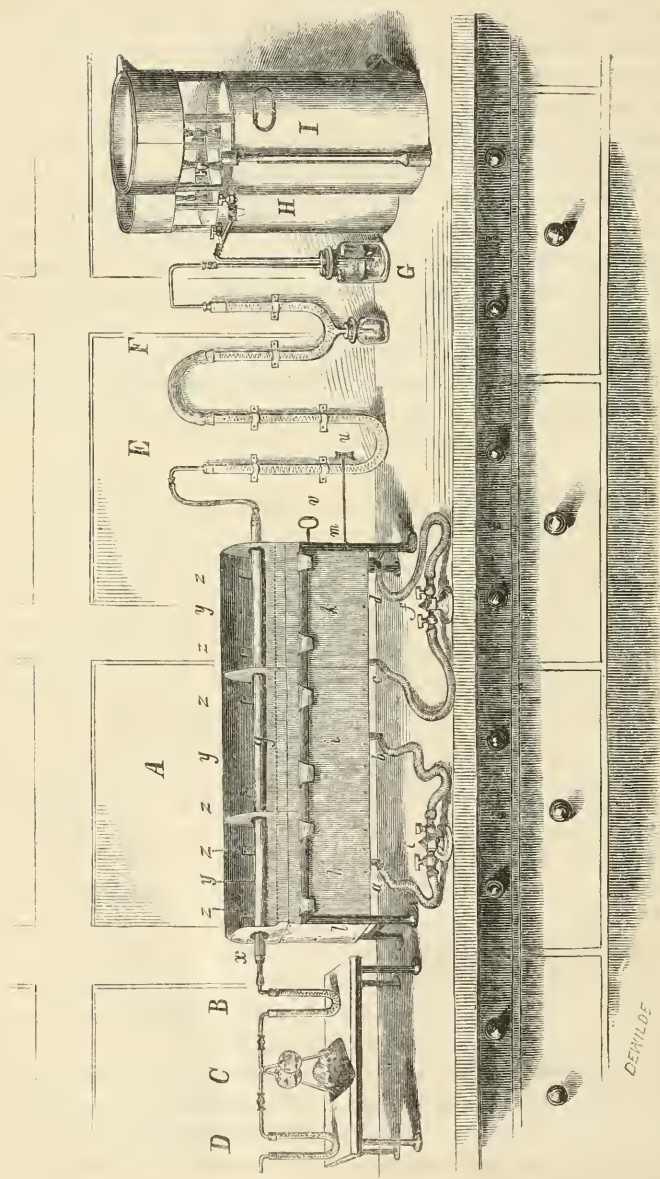
BY A. W. HOFMANN, PH.D., F.R.S.

The extensive and daily increasing application of gas as a source of heat in the laboratory, naturally suggested the idea of using this convenient fuel likewise in organic analysis. A variety of arrangements have been proposed for this purpose, but not one of them has as yet come into general use. The difficulties which present themselves are, in the first place, the production of a sufficiently high temperature; and secondly, the regulation of the heat according to the special requirement of the process. In order to accomplish the analysis at the temperature of an ordinary air-flame, it has been found necessary to abandon the simple process of Liebig, and to have recourse to the more complicated method of completing the combustion in an atmosphere of oxygen; on the other hand, in order to obtain a sufficient control over the temperature, an arrangement has been devised, which may appear intricate at the first glance, but which works with sufficient facility and precision, although it may hereafter probably be simplified.

The general disposition of the apparatus differs but little from the arrangement used in performing the combustion in oxygen-gas by means of spirits of wine, and is sufficiently intelligible by a glance at Fig. 1.* *A* is the combustion-furnace, which is supplied with gas by

* The wood engravings are taken from Liebig's "Handbook of Organic Analysis," edited by A. W. Hofmann. London, Walton and Maberly, 1853.

FIG. 1.



the tubes *a b c d*, communicating with two pairs of stopcocks, *e* and *f*;
 a combustion-tube, *g*, open at both extremities and supported in the

usual manner, communicates in front with the chloride-of-calcium-tube *B*, a potash-bulb-apparatus *C*, and a potash-tube *D*; at the back, the combustion-tube communicates by means of a system of desiccators, consisting of a potash-tube *E*, a sulphuric-acid-tube *F*, and a sulphuric-acid-bottle *G*, with the gas-holders *H* and *I*, containing respectively oxygen and atmospheric air. The bottle *G* serves, moreover, as a bubble-gauge for measuring the rapidity of the current.

The furnace consists of three separate compartments of strong iron plate *h i* and *k*, which are supported by a stout iron stand *l m*. The arrangement of these compartments requires a few explanations; their construction is evident from Figs. 2 and 3; *h* and *i* are simply

FIG. 2.

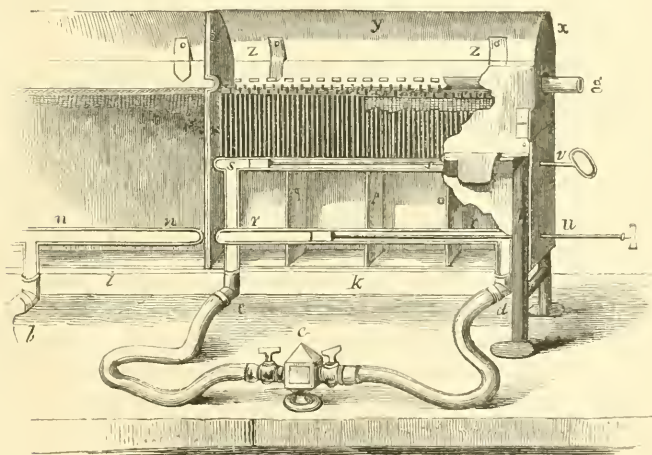
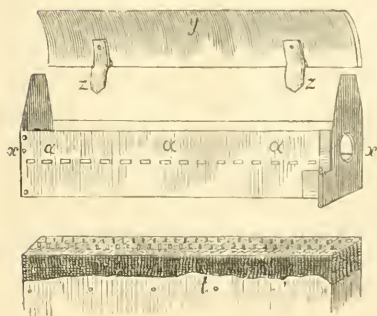


FIG. 3.



rectangular iron boxes, open at the bottom and covered at the top, with wire-gauze, which are supplied by horizontal perforated gas-pipes (*n n*, Fig. 2). The last compartment *k* (Fig. 2) has a somewhat more complicated construction. It differs from the two others by being subdivided into four smaller chambers by the three diaphragms, *o*, *p* and *q*, of iron plate, the gas being supplied by

two pipes instead of one. The lower pipe *rr* resembles in every respect the gas-pipe *nn* of the other compartments. The upper pipe *ss*, on the other hand, supplies the gas to two rows of vertical fine tubes, somewhat similar to those used in Leslie's gas-burner, the extremities of which project through the wire-gauze cover of the compartment (Fig. 3). Both pipes are provided with air-tight pistons, which enable the operator to manage the heat produced by this part of the apparatus according to the requirements of the analysis. Fig. 3 shows the manner in which the frame *x* which supports the combustion-tube is fitted over the wire-gauze cover of the case. It is provided with a series of holes *a*, allowing a current of air to enter, which bends the flame round the combustion-tube; this figure gives, moreover, a separate view of one of the side-pieces *y*, which by means of the tongues *z* are fastened upon the frame, in order to form a kind of dome, from which the heat is reflected downwards upon the combustion-tube.

The combustion is conducted in the following manner: A combustion-tube, open at both ends, and 2 or 3 inches longer than the combustion-furnace, is filled with a layer of oxide of copper, corresponding to the length of the two compartments *h* and *i*, placed into the furnace and connected at one end with the desiccators *E F*, &c., the other end being open at the time. The tube is then heated by the air-flame of the three compartments, and a slow current of dry air forced through it by means of the gas-holder *I*, for about five minutes, which removes every trace of moisture. The current being interrupted, the front end is corked, and the supply of gas so far diminished in compartments *h* and *i* that a mere sheet of flame remains upon the wire-gauze, whilst it is entirely turned off from the compartment *k*. As soon as the tube has sufficiently cooled, the front end is connected with the chloride-of-calcium-tube *B*, the potash-bulbs *C*, and the potash-tube *D*, and a little platinum boat containing the substance to be analyzed, introduced at the other extremity, and pushed in about two-thirds of the division *k*. All joints being well secured, the gas is again fully supplied to compartments *h* and *i*, and the layer of oxide of copper corresponding to the length of these divisions heated to a dull redness. The distillation of the "substance" may now be commenced. For this purpose, the gas is admitted, by means of the flexible tube *d*, to the lower gas-pipe *rr*, and the piston *u* pushed so far from the inlet as to supply the gas to the chamber *ol* only, whilst it is excluded from the other chambers, Fig. 2. In this manner, an air-flame is obtained which keeps the posterior extremity

of the combustion-tube at a dull red heat. A small quantity of gas is next admitted to the upper gas-pipe *s s*, by means of the flexible tube *c*, the piston *r* being drawn so far from the inlet as to confine the gas to a very few of the little tubes, at the extremity of which mere points of flame are thus produced. The distillation now proceeds with perfect regularity, the slow air-current, which must be kept up all the while, as well as the high temperature of the posterior portion of the tube, driving all the products of combustion towards the red-hot oxide of copper, which effects their perfect combustion. The piston *v* is gradually drawn out, so as to bring all the jets into play, and the supply of gas to the jets increased as far as possible without producing too smoky a flame. As soon as the temperature of the jets is no longer capable of expelling volatile matter from the substance, the piston *u* of the lower tube is gradually pushed in, and the gas supplied to all the chambers of compartment *k*, until the whole of the combustion-tube is exposed to an uniform air-flame throughout its whole length. A new quantity of matter is thus expelled, but unless the substance under examination be volatile, a large quantity of carbon is left in the boat.

At this period the air-current is replaced by a slow stream of oxygen from the gas-holder *H*, the arrival of which in the combustion-tube is marked by a brilliant phenomenon of incandescence. After a few minutes, the boat is left clean, and the combustion is terminated. The current is, however, kept up for a very short time longer, and stopped only when pure oxygen may be traced at the mouth of the potash-tube by means of an ignited splint of wood.

By this time the products of combustion are perfectly swept from the tube, and lodged in their receptacles; moreover, the copper is completely re-oxidized; the flame is now gradually lowered, and the gas at last entirely turned off; and if the combustion-tube, after the detachment of the chloride-of-calcium-tube, &c., and the removal of the empty platinum boat be carefully corked, the whole arrangement is ready for another combustion, in which the operation of drying, of course, becomes unnecessary.

Liquids may be likewise burned with the apparatus; in fact, on account of the facility with which the temperature of the compartment *k* can be managed, this mode of proceeding is particularly adapted to liquids. Even very volatile liquids, such as ether, &c., may be safely burned; in this case the combustion can be completed without any oxygen, and no fear of an explosion need be entertained.

In the case of substances containing nitrogen, the copper turnings

perfectly dried in a current of hydrogen, must be placed into the combustion-tube, *after* the preliminary desiccation, and the current of air must be very slow; it is, moreover, advisable to place some copper-turnings behind the boat with the substance, over the posterior compartment; the copper is thus heated to redness, and deprives the air-current of the greater part of its oxygen.

The first putting together of this apparatus requires considerable time, and the securing of so many joints is attended with some difficulty; but once fitted up, it enables the operator to analyze with great dispatch, scarcely more than an hour being necessary for making a complete combustion. The arrangement is particularly useful when a considerable number of analyses have to be made. There are, moreover, several additional advantages which deserve to be noticed. The determinations, both of carbon and hydrogen, are very exact, especially the latter, all sources of accidental moisture being excluded. On this account it is possible to reduce the amount of substance used in the analysis to a minimum, not more than from 150 to 200 milligrs. being required. The possibility of determining the amount of ash or the quantity of silver, platinum or barium, &c., in a substance, together with the carbon and hydrogen, is likewise frequently a very great convenience. The number of accidents is, moreover, much smaller. The combustion-tubes very rarely crack if the application of heat be sufficiently gradual. For this purpose it has been found convenient to light the gas in the commencement, below the wire-gauze, until the furnace has become hot, then to turn it off and to light it above the wire-gauze. But if an accident actually take place with a combustion-tube, it almost invariably occurs in the preliminary heating of the oxide of copper, and in such cases the "substance" is perfectly safe, and has only to be shifted to another tube. The combustion-tubes usually stand six or eight combustions, but frequently as many as ten or twelve may be made with the same tube, so that there is also a considerable saving in expense.

The only inconvenience incident to the apparatus is, that it is liable to get out of order. The wire-gauze especially has to be often renewed, and on this account a construction has been selected, which renders it possible to replace the wire-gauze in the laboratory, without sending the furnace to a gas-fitter.

The furnace given in the above illustrations is composed of three distinct divisions, which may be separately fixed upon the support. By this provision the apparatus becomes adapted to a variety of operations, especially to nitrogen-determinations, which require a shorter tube. This separation, however, is not absolutely necessary,

and for the special purpose of the carbon-, and hydrogen-determinations a furnace made in one piece answers equally well.

In conclusion, the results of several analyses performed by means of the above apparatus may be quoted.

Combustion of sugar :

I.	0.155	gm. of sugar gave
	0.240	„ carbonic acid, and
	0.092	„ water.
II.	0.3035	„ sugar gave
	0.4685	„ carbonic acid, and
	0.1765	„ water.
III.	0.226	„ sugar gave
	0.3493	„ carbonic acid, and
	0.1319	„ of water.

	I.	II.	III.	$C_{12}H_{11}O_{11}$
Carbon . .	42.16	42.09	42.17	42.10
Hydrogen . .	6.59	6.46	6.48	6.43

Combustion of benzoic acid :

	0.1695	gm. of benzoic acid gave
	0.4275	„ carbonic acid, and
	0.077	„ water.

			$C_{14}H_6O_4$
Carbon . . .	68.78	. .	68.85
Hydrogen . .	5.04	. .	4.91

Combustion of oil of turpentine :

	0.1185	gm. of oil of turpentine gave
	0.3842	„ carbonic acid, and
	0.1240	„ water.

			$C_{10}H_8$
Carbon . . .	88.42	. .	88.23
Hydrogen . .	11.62	. .	11.77

Combustion of ether :

	0.1561	gm. of ether gave
	0.3695	„ carbonic acid, and
	0.1915	„ water.

			$C_8H_{10}O_2$
Carbon . . .	64.55	. .	64.86
Hydrogen . .	13.62	. .	13.51

The preceding analyses were made by Mr. Charles Tookey for the especial purpose of testing the practicability of the gas-furnace. The following numbers are quoted from a paper shortly to be published by Messrs. Reginald Morley and John Abel :

Combustion of diethyltoluidine :

0·1495 grm. of diethyltoluidine gave
 0·4435 „ carbonic acid, and
 0·1410 „ water.

			$C_{22}H_{17}N$
Carbon . . .	80·90 . . .		80·98
Hydrogen . . .	10·47 . . .		10·43

Combustion of chloride of triethylo-toluammonium and bichloride of platinum :

0·530 grm. of salt gave
 0·760 „ carbonic acid,
 0·269 „ water, and
 0·131 „ of platinum.

			$C_{26}H_{22}NCl, PtCl_2$
Carbon . . .	39·10 . . .		39·24
Hydrogen . . .	5·63 . . .		5·53
Platinum . . .	24·71 . . .		24·90

An analysis of iodide of tetramethylammonium, likewise made by Mr. Tookey, gave the following results :

0·4138 grm. of iodide gave
 0·3626 „ carbonic acid, and
 0·2237 „ water.

			$C_8H_{12}NI$
Carbon . . .	23·89 . . .		23·89
Hydrogen . . .	6·00 . . .		5·97

XXI.—On the Acetates and other Compounds of Alumina.*

By WALTER CRUM, F.R.S.,

PRESIDENT OF THE PHILOSOPHICAL SOCIETY OF GLASGOW.

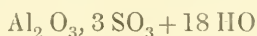
The salt from which most of the products described in the present memoir were produced, is the tersulphate of alumina, now manu-

* Read before the Philosophical Society of Glasgow, April 27, 1853.

factured in large quantity in the north of England, under the name of concentrated alum. It is formed by the direct action of sulphuric acid upon clay, and, after a certain purification, is evaporated and sold in cakes.

The impurity which the commercial article contains in largest quantity is potash-alum. To separate that substance advantage was taken of its insolubility in a saturated solution of the tersulphate. The cake-alum was dissolved in a quantity of boiling water insufficient for its entire solution in the cold. On cooling, the excess of sulphate of alumina, mixed with almost the whole of the potash-alum, deposited, and was separated by filtration through calico. The filtered solution was then evaporated and cooled, when the tersulphate was found to crystallize in granular spongy masses. It was then drained and separated as much as possible from the mother-liquor by strong pressure between numerous folds of calico. The product was redissolved in boiling water, and again crystallized and pressed.

A salt was thus obtained, having little more than traces of the arsenious acid and the potash of the original material, together with a little iron and chloride of sodium. It has the formula



first observed in 1825 by Boussingault in the hair-like substance found among the black schistus of the Andes of Columbia, near Bogota. He afterwards found the same substance in the volcano of Pasto, (north of Quito,) where it is formed by the action of the sulphurous vapours upon the schistus. It exists there in such quantities as to have enabled the Pastusos to become the manufacturers of chemical products for the whole country. They dissolve the alum in water, evaporate it to dryness, and form it into spherical masses like camphor, which are altogether free from iron.

The same substance is formed in this neighbourhood from a schistus containing pyrites, in which case it is mixed or combined with sulphate of iron.

The quantity of cake-alum now produced annually at

Newcastle and at Sowerby-bridge, according to statistics furnished me by Mr. Wilson of Hurler, is .	1,500 tons.
And of crystallized alum (chiefly ammoniacal) in	
England	13,200 „
Ditto ditto ditto in Scotland	4,200 „

Total in Great Britain . . . 18,900 tons.

It is estimated by Mr. Wilson that about one-fourth of this quantity

is consumed by calico-printers, and converted more or less completely into acetate of alumina. There is no other example of a substance so important and so extensively employed in the arts, as acetate of alumina, having been so little attended to by chemists.

INSOLUBLE ACETATES OF ALUMINA.

I. *Insoluble Binacetate of Alumina.* (5—*Hydrate*).—An acetate of alumina was produced by mixing together strong solutions of tersulphate of alumina (purified as already described) and of acetate of lead. They were poured slowly together into a vessel surrounded with cold water, and much agitated to reduce the temperature of the mixture. To the filtrate was added sulphide of hydrogen, to precipitate the lead of the sulphate of lead which remained in solution; and acetate of baryta to throw down its sulphuric acid.

The strongest solution formed in this way contained about 5 per cent of alumina, (from about 6 lbs. acetate of lead in an imperial gallon of the mixture).

When such a solution (or one containing even 4 per cent of alumina) is set aside and left at rest at a temperature of 60° or 70° Fahr., it begins after four or five days (without losing much of its transparency) to deposit upon the vessel a crust, which continues for some time to increase in thickness. When the liquid is poured off, and the crust allowed to dry, it separates readily from the vessel in hard plates like porcelain. If the solution be not left strictly at rest, it becomes turbid after some days, and the crust is produced in a more friable state. In cold weather the solution remains unaltered for a much longer time. Heated to redness, the salt becomes black from the decomposition of part of its acetic acid, and in this state it very slightly affects the colour of moistened litmus-paper, showing that it retains but little alkali. Dissolved in nitric acid and tested with nitrate of silver, it showed a trace of chlorine. It was freed entirely from these impurities by the process detailed in the succeeding chapter; still retaining, however, a trace of iron.

To ascertain the quantity of alumina in one of these salts, it is enough to moisten it with rectified and concentrated sulphuric acid in a platinum crucible, to evaporate the excess of acid over a spirit-lamp, and then to subject it to a white heat for half-an-hour in a furnace. The sulphuric acid expels acetic acid, and thereby secures the absence of charcoal. It facilitates the disengagement of water; and the powder, which, without it, becomes so pulverulent by calcination as to be with difficulty prevented from escaping, is thereby rendered coherent.

Attempts were first made to determine the acetic acid by the alkalimeter, taking potash-alum of known purity for a standard, and for a comparison of results. The substance being kept in water at a boiling-heat during the addition of the alkali, (soda,) and by a careful comparison of the shades of the litmus-paper, appeared at first to redden that test, so long as any portion of the salt remained undecomposed. But it was found, after some practice, that at least 5 per cent of the insoluble salt remained untouched by the alkali after all trace of acid reaction had disappeared in the process, and that within a range of 3 or 4 per cent the method was not to be depended upon. It gave valuable assistance, however, in this investigation, in the testing of solutions of alumina, with which it gave results much more accurate than with the insoluble salts.

33·24 grs. of the substance, dried first in the air, then pulverized and dried further in a stove twenty hours at 100° Fahr., were moistened with 80 grs. of rectified sulphuric acid in a platinum crucible, and calcined as above. There remained 8·64 grs. When this residue was treated with water and filtered, the solution showed no trace of sulphuric acid, and was alumina nearly pure= $25\cdot99$ per cent of the original substance.

In another experiment, 32·64 grs., dried four hours in the stove, and treated as above, left 8·4 grs. of alumina= $25\cdot74$ per cent. The mean is $25\cdot86$ per cent of alumina.

Burned with oxide of copper, 2·985 grs. produced 5·526 cub. inches of dry carbonic acid= $2\cdot612$ grs., and corresponding to $50\cdot69$ per cent of acetic acid. In another experiment 1·685 grs. indicated $50\cdot58$ of acetic acid. The mean is $50\cdot63$. It was assumed that the remaining $23\cdot51$ per cent was water. The salt was therefore composed of—

Acetic acid	.	.	.	50·63
Alumina	.	.	.	25·86
Water	.	.	.	23·51
				100·00

The formula, $\text{Al}_2\text{O}_3, 2\bar{\text{A}} + 5\text{HO}$, requires—

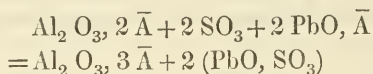
Acetic acid	.	.	.	51·41
Alumina	.	.	.	25·91
Water	.	.	.	22·68
				100·00

11. *Insoluble Binacetate of Alumina.* (2—Hydrate.)—If heat

be applied to the strong solution of acetate of alumina, described in the previous pages, it speedily becomes turbid, and deposits a heavy white powder, which falls readily to the bottom of the vessel. In a couple of days, at 100° Fahr., a considerable quantity of this powder is deposited; but in two or three hours at 160° , and in much shorter time at boiling heat, the whole of the salt is thrown down, and nothing remains in the liquid but acetic acid, excepting a trace of alumina, just distinguishable by carbonate of soda.

The precipitate has a crystalline shining appearance in the moist state, and seems, under the microscope, to consist of small oval particles of uniform size. It falls into fine powder in drying, after which, when mixed with water, it remains for a long time in suspension. Boiling water does not free it from chloride of sodium, of which it contains about 0.1 per cent.

To remove that impurity, the substance is to be dissolved with the assistance of heat in 2 equivs. of rectified sulphuric acid, diluted with three times its weight of water. The solution is decomposed by subacetate of lead—



and the filtrate freed from lead and sulphuric acid as before. When heat is now applied to this solution, a precipitate is obtained, in which no trace of alkali or of chlorine can be detected.

A portion of the substance obtained at a boiling heat, and dried twenty-four hours at 100° Fahr., yielded 29.83 per cent of alumina. Another portion dried forty-eight hours gave 30.54 per cent. Burned with oxide of copper, 1.697 grs. of the salt, dried at 100° Fahr., indicated 59.87 per cent of acetic acid. In another experiment 1.605 grs. indicated 58.88 per cent. The mean is 59.37. The substance is, therefore, composed of—

Acetic acid	.	.	.	59.37
Alumina	.	.	.	30.18
Water	.	.	.	10.45
				100.00

The formula, $\text{Al}_2 \text{O}_3, 2 \bar{\text{A}} + 2 \text{HO}$, requires—

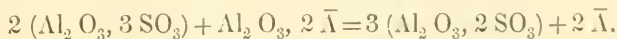
Acetic acid	.	.	.	59.51
Alumina	.	.	.	29.99
Water	.	.	.	10.50
				100.00

Numerous specimens of this salt were formed by precipitation from solutions of various strengths, at various temperatures below boiling water, and analyzed for acetic acid and alumina. They generally agreed in the proportions of acid and base, but varied in the absolute quantity; indicating a range of from 3 to 5 equivs. in the proportions of water. The two salts which have been described as deposited, one at 60° and the other at a boiling heat, gave results nearly uniform.

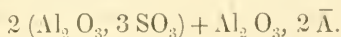
When heat is applied to a solution of teracetate of alumina weaker than that which has been described, to one, for example, containing 3 per cent of alumina, it also yields the insoluble binacetate, but, in that case, not acetic acid alone, but a considerable quantity of acetate of alumina remains in the solution. Solutions containing 2 per cent of alumina are precipitated by boiling, if they have been kept some weeks, but not if recently prepared. It appears from these experiments, that the presence of free acetic acid favours, in some way, the production of the insoluble binacetate of alumina from a solution of teracetate. It was found, accordingly, that a solution of teracetate containing $\frac{3}{4}$ per cent of alumina, and which could not therefore be precipitated by boiling, acquired that property when made to contain acetic acid equal to a solution of teracetate with 4 per cent of alumina.

In whichever way deposited, this substance is exceedingly insoluble in water, either cold or hot, and it is equally insoluble in acetic acid. When 1 part of it is digested for an hour and a half in 200 parts of boiling water, it dissolves; and the solution consists partly of soluble binacetate of alumina, and partly of acetic acid and the bihydrate of alumina, to be afterwards described.

It dissolves in 2 equivs. of sulphuric acid, or of hydrochloric, or nitric acid, forming bisalts of alumina, and liberating the 2 atoms of acetic acid. It also dissolves in a strong solution of tersulphate of alumina, with the assistance of heat, forming bisulphate of alumina and free acetic acid.

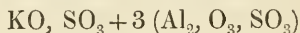


The mixture does not precipitate on the addition of water like the bisulphate alone, and must therefore be changed by water into tersulphate and binacetate of alumina.

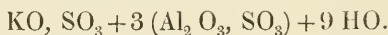


A solution of potash-alum dissolved this binacetate in the same circumstances, but on the heat being continued for some time, a

precipitate was formed anew, which appeared from a qualitative analysis to be the monosulphate of alumina and potash,



the substance which is formed when hydrate of alumina is boiled with alum. The same substance is found native, under the name of aluminestone, at La Tolfa, the seat of the celebrated manufacture of Roman alum, near Civita Vecchia; and was ascertained, by Collet Descotils, to be formed of—



SOLUBLE ACETATES OF ALUMINA.

Soluble Binacetate of Alumina. $\text{Al}_2 \text{O}_3, 2 \bar{\text{A}} + 4 \text{HO}$.—Notwithstanding the tendency of a concentrated solution of the teracetate of alumina to deposit the insoluble salt, it may be evaporated, with certain precautions, to a dry substance soluble in water. For this purpose it must be spread very thin over sheets of glass, or of porcelain, exposed to a heat not exceeding 100° Fahr., and, as it runs together into drops, like water upon an oiled surface, it must be constantly rubbed with a thin platinum or silver knife. If these precautions are neglected, a mixture is obtained of the insoluble with a soluble acetate.

The soluble salt is thus produced in scales, having the appearance of gum when moistened, and leaving no residue when dissolved in water.

For analysis it was reduced to powder, and dried in the air twenty-four hours, at the temperature of 100° Fahr. The alkalimetric method was first employed, and it indicated 54.8 per cent of acetic acid; but the more accurate method, by oxide of copper, gave 55.82 per cent of acid. In experiments for the alumina 26.4 per cent was obtained. The composition of the substance was thus—

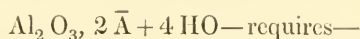
Acetic acid	.	.	.	55.82
Alumina	.	.	.	26.40
Water	.	.	.	17.78
				100.00

But the solution from which this substance was obtained was a teracetate, and contained for the same quantity of alumina,

Acetic acid	.	.	.	78.58
-------------	---	---	---	-------

It lost, therefore, during gentle evaporation, nearly one-third of its

acetic acid, and was reduced almost to a binacetate, the formula of which—



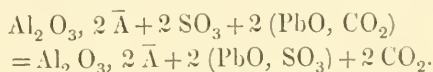
Acetic acid	.	.	.	52·38
Alumina	.	.	.	26·40
Water	.	.	.	18·49
				97·27

The excess of acetic acid = 3·44 per cent over the proportions of a binacetate, was presumed to be free acid adhering to the product. To remove that excess, a portion of it was heated in a water-bath, and afterwards treated with water. A considerable quantity of insoluble matter was left, and the solution on being evaporated to dryness, at a gentle heat, produced a soluble acetate, of which 100 parts contained—

Of acetic acid	.	.	.	49·55
And of alumina	.	.	.	32·47

corresponding, therefore, in composition, to a sesquiacetate; but it can only be looked upon as an accidental mixture, for every fresh portion that was produced in a similar way gave a different result—the amount of acid depending upon the extent and duration of the heat.

The binacetate of alumina may be produced at once in solution; and as it is the most suitable combination from which to form the dry soluble binacetate, as well as other bodies, I shall describe particularly the manner of obtaining it. Dissolve 24 parts of precipitated binacetate of alumina in 15 of rectified sulphuric acid, and 40 of water. Dilute further with 100 parts of water, and add carbonate of lead (about 44 parts) to precipitate the sulphuric acid.



Filter the solution, and pass sulphide of hydrogen through it until it ceases to precipitate lead, and then add acetate of baryta, so long as it is precipitated by the sulphuric acid of the sulphate of lead which had remained in solution. When in this state, if the mixture be well agitated for half an hour in an open vessel, the excess of sulphide of hydrogen will be removed, and it may be filtered without the danger of the filtrate becoming afterwards milky. A solution of binacetate of alumina is thus obtained, containing about 4 per cent of

alumina, which is the strongest solution, even of the binacetate, that can be preserved for a length of time without depositing an insoluble salt.

Spread very thinly over a sheet of glass, it evaporates at 60° or at 100° Fahr., without running into large drops so much as the teracetate, and without having an equal tendency to produce the insoluble binacetate. The scales into which it forms in drying are transparent and soluble in water.

Burned with oxide of copper for acetic acid, and calcined for alumina, 100 parts were found to contain—

Acetic acid	.	.	.	55.21
Alumina	.	.	.	31.31

But the alkalimeter had shown, that in the solution the same quantity of alumina had been combined with—

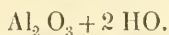
Acetic acid	.	.	.	59.13
-------------	---	---	---	-------

More than 4 per cent therefore had been lost by evaporation at 100° Fahr.

After some other attempts, I was obliged to conclude that the only way to obtain the dry soluble binacetate in something like atomic proportions, was the unsatisfactory one of evaporating in the air a solution of binacetate, mixed with such a proportion of acetic acid or of teracetate as is found by trial to produce it.

On the question, as to which of the soluble acetates of alumina can be considered as a definite compound, it has already been stated of the teracetate, that when evaporated rapidly enough, and at a heat just low enough to prevent the formation of the insoluble salt, it leaves a product whose composition is nearly that of a binacetate. It may be added, that the solution of teracetate gives off acetic acid as freely in the cold, as if a third part of its acid were free. On making an experiment with two solutions of acetate of lead—one of which was decomposed by sulphuric acid, and the other (which was three times as strong) by tersulphate of alumina—it was found that the aluminous solution gave a smell of acetic acid considerably stronger than that in which the acid was known to be free. It may be doubted, then, whether there exists a combination of acetic acid with alumina corresponding to the tersulphate of alumina. The solution of binacetate has no smell of acetic acid at ordinary temperatures.

BIHYDRATE OF ALUMINA SOLUBLE IN WATER.



Hydrate from the Soluble Binacetate.—By the continued action of heat on a weak solution of binacetate of alumina, a permanent separation of the constituents of the salt takes place, although no acid escapes, and no alumina is precipitated. The properties of the alumina are at the same time materially changed.

A solution of binacetate of alumina, diluted so as to contain not more than 1 part of alumina in 200 of water, was placed in a close vessel which was immersed to the neck in boiling water, and kept in that state day and night for ten days. It had then nearly lost the astringent taste of alum, and acquired the taste of acetic acid. Being afterwards boiled in an open capsule, acetic acid was freely given off, and when the boiling had continued about five hours (the loss of water being continually restored,) the liquid was found to have retained not more than $\frac{1}{11}$ of its original quantity of acetic acid, or about 1 equiv. to $5\frac{1}{2}$ of alumina.

The solution of hydrate of alumina thus obtained has nearly the same transparency as before the loss of its acid, and is slightly oily. It is nearly tasteless. By longer boiling it may be deprived of considerably more of its acid, but there is a danger of coagulation.

A solution containing $\frac{1}{4}$ per cent of alumina is converted into a solid transparent jelly, when mixed with half its bulk of water acidulated with $\frac{1}{2500}$ of sulphuric acid. The jelly has therefore only $\frac{1}{600}$ of its weight of alumina, and $\frac{1}{7500}$ of sulphuric acid.

By pressure in a bag the liquid part of this jelly was readily separated, and the solid was reduced to $\frac{1}{600}$ or $\frac{1}{700}$ of its original volume. Pure water did not dissolve this residue, neither did an excess of sulphuric acid, even at a boiling heat. On examination it was found that the solid portion had imbibed almost the whole of the sulphuric acid. It existed there in the proportion of about 1 equiv. of acid to 15 of alumina.

The coagulating power of the various agents may be ascertained with tolerable accuracy by employing an aluminous solution so dilute as to contain not more than 1 part of alumina in 800 of water, and shaking it in a phial with about half its volume of a coagulating solution. In this manner it was found that 1 atom of citric acid (tribasic) coagulates as powerfully as 3 atoms of sulphuric acid, and tartaric acid (bibasic) as much as 2. 2 atoms of oxalic acid are required to produce the same effect as 1 of sulphuric acid. Of

muriatic and nitric acids, not less than 300 equivs. must be employed to produce an effect equal to that of 1 equiv. of sulphuric acid—the volume of the acid being always $\frac{1}{2}$ that of the aluminous solution. No acid has the power of redissolving the coagulum.*

Of the other acids which have been tried, the chromic, molybdic, racemic, suberic, salicylic, benzoic, gallic, lactic, cinnamic, butyric, valerianic, carbazotic, camphoric, uric, meconic, comenic and hemipinic acids all coagulate the solution; but their exact power has not been ascertained.

The acetic, formic, boracic, arsenious, and cyanuric acids do not coagulate, at least when moderately concentrated; and, of the opium acids, for a supply of which I am indebted to Professor Anderson, the pyromeconic and opianic acids also do not coagulate.

The alkalies have a strong coagulating power. About 2 equivs. of potash produce an effect equal to 1 of sulphuric acid, and the same is the case with soda, ammonia, and lime. The coagulation takes place before the acetic acid which remains in the aluminous solution is fully saturated; for when the alkali, in a very dilute state, is added with caution, the coagulum which it produces has still an acid reaction. This coagulum, like that from sulphuric acid, is insoluble in any acid, whether cold or hot, as well as in pure water. It dissolves, however, in a boiling solution of potash or soda, and when the alkaline solution is afterwards saturated by an acid, the ordinary terhydrate of alumina is thrown down.

Large quantities, however, of the acetic salts (ready formed) may be added before they coagulate the aluminous solution.† When the solid part of the coagulum produced by a strong solution of acetate of soda was afterwards freed from that salt by pressure, it redissolved in pure water, and the solution was again coagulated by a fresh addition of the salt. An experiment with acetate of lime gave the same result.

The nitrates and chlorides coagulate also with great difficulty.

Solutions of sulphate of soda, magnesia, and lime coagulate as readily as a liquid containing the same quantity of sulphuric acid in the free state. On examining one of these mixtures, the sulphuric

* Since these experiments were concluded, it has been found that by employing a wider and shallower porcelain vessel, it is possible to boil off, in an hour and a half, a much larger proportion of acetic acid than that which is mentioned in the text as being done in five hours; and to obtain a product equally fluid.

† Hence, in preparing the binacetate of alumina, which is to be used in obtaining the bihydrate, it is better to employ an excess of acetate of baryta, than to leave in the solution the slightest trace of sulphuric acid.

acid was found in the solid part of the coagulum, as before, and the alkali in the fluid part, united with the acetic acid which had remained in the aluminous solution after boiling.

The digested solution of alumina which has not been deprived of its acetic acid by boiling, requires about twice as much sulphuric acid to coagulate it as does the boiled solution, and thirty or forty times as much alkali. The coagulation is complete before the acetic acid is entirely saturated.

One of the most characteristic properties of the digested and altered acetate of alumina is its loss of the power of acting as a mordant. The ordinary acetate, as is well known, forms a yellow opaque precipitate with decoction of quercitron. That which has been thoroughly digested is merely coagulated by that decoction—the colour of which is but little altered, and the coagulum is translucent. The same effect is produced with decoctions of logwood, brazil-wood, &c.

Analysis of the Soluble Hydrate of Alumina.—A quantity of the digested and boiled solution of hydrate of alumina, which had been found to contain acetic acid in the proportion of about 1 equiv. to $5\frac{1}{2}$ of alumina was evaporated to dryness at 100° Fahr. From the escape, by that means, of its free acetic acid, the proportion of acid was reduced to 2.76 per cent of the dry residue, or about 1 equiv. of acid to 22 of alumina. Not more, therefore, than $\frac{1}{44}$ of the original binacetate had resisted decomposition in the process of digestion and subsequent boiling, and at least 97.8 per cent of its alumina had been changed into the peculiar hydrate. To deprive it, as much as possible, of the remaining acid, and also of hygrometric water, it was exposed for some time to the heat of boiling water. After losing 16.00 per cent of acid and water, it recovered 14.18 per cent when again exposed during twelve hours to the air.

The product, on being moistened with sulphuric acid, as before described, and heated to whiteness, lost in one experiment 24.9, and in another 24.88 per cent. It consisted therefore of

Alumina	75.11
Water, and a trace of acetic acid	24.89
	100.00

and approached to the composition of a bihydrate which requires—

Alumina	74.06
Water	25.94
	100.00
	Q 2

Hydrate from the Insoluble Binacetate.—It has been already mentioned that when the precipitated binacetate is kept for an hour or two in 200 parts of boiling water, it is changed into the soluble binacetate. The substance so produced may be converted, like the original solution, into the peculiar bihydrate. Thirty to thirty-six hours digestion is sufficient to complete the change, for after that time the solution has no longer any taste of alum, and the power of coagulating with acids does not increase. A portion of it was boiled in an open vessel eleven hours, being retained at the strength of $\frac{1}{2}$ per cent of alumina by successive additions of water. The solution remained quite clear, and became very slightly oily. It then contained only about 1 equiv. of acetic acid to 19 of alumina. This preparation may be considered as free from all other foreign matter, with the exception of a trace of iron, which still adheres to it. As compared with the solution prepared at once from the soluble binacetate, smaller quantities of the reagents are sufficient to coagulate it, and the coagulum produced has not more than half the density. 0.03 gr. of sulphuric acid, or 0.06 gr. of sulphate of soda is sufficient to coagulate 1.5 grs. of alumina in 600 grs. water, being in the proportion of about 1 equiv. of sulphuric acid to 35 of alumina. An equal quantity of the solution was completely coagulated by 0.034 gr. of potash and by 0.020 gr. of ammonia. In both of these experiments the acetic acid was not fully saturated. The alkalies then are equivalent in coagulating power to sulphuric acid when a very small quantity only of acetic acid is present in the solution.

6.93 grs. of this hydrate, which had been dried at a steam heat, were moistened with sulphuric acid, which was then gradually expelled by a spirit-lamp, and the residue, when kept forty minutes at a white heat, left 5.20 grs. of alumina, showing that the hydrate was composed of—

Alumina	75.03
Water	24.97
	100.00

and contained, therefore, 2 equivs. of water, like the hydrate obtained directly from the soluble binacetate.

ACETATE OF SESQUIOXIDE OF IRON.

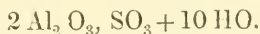
The analogy between the salts of alumina and those of the red oxide of iron, induced me to inquire whether there might not exist allotropic acetates of iron, corresponding with those of alumina.

A solution of sulphate of iron, to which was added $\frac{1}{2}$ an equiv. of sulphuric acid, was acted upon by strong nitric acid, and the tersulphate so obtained was converted into the teracetate by decomposition with neutral acetate of lead. A binacetate was also produced by decomposing with a mixture of acetate and carbonate of lead. Both solutions had the same intense red colour which is peculiar to the peracetate of iron.

The teracetate of iron, whether concentrated or weak, is little liable to decomposition in the cold. Boiling causes the deposition of a hydrated peroxide, but the decomposition is only partial, and the hydrate difficult to collect.

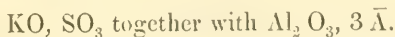
The binacetate soon begins to let fall an oxide in the cold; and at the heat of boiling water a complete separation takes place. A rich, deep-coloured hydrate goes readily down, and the whole of the acetic acid remains in the liquid, which is perfectly colourless. No allotropic acetates of iron, corresponding to those of alumina, appear therefore to exist.

BIBASIC SULPHATE OF ALUMINA.



It is well known that when teracetate of alumina is boiled along with sulphate of potash, a gelatinous precipitate is formed, which redissolves when the solution becomes cold. M. Kœchlin-Schouh* found it to be a subsulphate of alumina.

When alum, dissolved in six times its weight of water, was treated with 3 equivs. of acetate of lead—enough to decompose its tersulphate of alumina, but not the sulphate of potash, a large proportion (74 per cent) of the sulphate of potash was found to be carried down by the sulphate of lead formed in the process. To a solution so prepared, the loss was restored by an addition of sulphate of potash, and a mixture formed of—



This solution, diluted so as to contain about 0.3 per cent of alumina, (from 5 oz. of alum per gallon,) was exposed to heat. At about 90° Fahr., the gelatinous precipitate began to form; and after two hours' boiling, when scarcely a trace of alumina remained in solution, it was thrown upon a filter of calico, which was kept hot within a steam-pan until the filtrate passed through. The collected precipitate was pressed between numerous folds of bleached calico, and brought

* Sur le Mordant Rouge, &c. Bulletin de la Société Industrielle de Mulhausen. I. 299.

gradually to the state of a stiff clay occupying not more than $\frac{1}{40}$ of the volume of the original solution. It was then divided into portions which could conveniently be shaken and thoroughly mixed in bottles with quantities of water equal in all to the original solution. The mixture was filtered as before, at nearly a boiling heat, and pressed between folds of calico; and another repetition having been made of the same process, the precipitate was deprived of every admixture of soluble matter.

A portion being dissolved in nitric acid and filtered, gave an abundant precipitate with nitrate of baryta. Exposed to a white heat, and the residue pulverized and boiled in water, the filtered liquor gave no longer a precipitate with nitrate of baryta, and no indication, or a very doubtful one, of alkali to litmus-paper; proving that the sulphuric acid indicated by the first test had been combined, not with potash, but with alumina. Mixed with sulphuric acid, the substance gave no smell of acetic acid, and when burned with oxide of copper it yielded no more carbonic acid than could readily be accounted for by the few fibres of cotton-wool that were to be distinguished in the liquid. The substance dried into a hard, whitish, semi-transparent matter, easily pulverized.

For analysis, 33·93 grs. dried at 100° Fahr. were dissolved in muriatic acid, and the solution was exactly decomposed at a boiling heat by 15·25 grs. of chloride of barium.* This indicates 5·867 grs., or 17·29 per cent of sulphuric acid. 19·715 grs. mixed with 16 grs. of sulphuric acid in a platinum crucible were first heated with a spirit-lamp, and then exposed to a white heat. It left 8·51 grs. = 43·16 per cent of alumina. Another experiment gave 42·94 per cent. The mean is 43·05. The composition of the substance is therefore—

Sulphuric acid . . .	17·29	SO ₃ . . .	17·18
Alumina . . .	43·05	2 Al ₂ O ₃ . .	44·16
Water . . .	39·66	10 H ₂ O . .	38·66
	100·00		100·00

* The heat in this case greatly facilitates the arrival at the nearest point of decomposition, particularly by enabling the filter to furnish, immediately, clear portions, from time to time, for testing. Where nitrate of baryta is employed for decomposing a sulphate, it was observed by Mitscherlich that a quantity of the nitrate was taken down unaltered by the sulphate of baryta. This source of error, which amounts to no less than 5 per cent of the quantity of sulphuric acid when the experiment is performed in the cold, is entirely obviated at a boiling heat. Boiling, however, does not render the decomposition of a sulphuric salt by a salt of baryta complete without a considerable excess of the barytic salt, and *vice versâ*. The point sought for in the present instance is that at which an equal precipitate is formed on adding an excess of either salt.

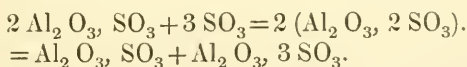
When the solution from alum and sugar of lead was heated before the restoration of its sulphate of potash, a very slight precipitate was formed. The addition of that salt completed the precipitation, but the substance thrown down was more transparent, and dried into a brownish, horny-looking matter. Its analysis, however, gave nearly the same results.

Sulphuric acid	17·23
Alumina	43·51
Water	39·26
	100·00

But when the solution was boiled for two hours before the addition of the sulphate of potash, a quantity of alumina seems to have gone down with the sub-sulphate, for its analysis gave in 100 parts

Sulphuric acid	13·73
Alumina	50·71

It had an appearance similar to the preceding product. In the moist state the sub-sulphate is soluble in cold acetic acid, as well as in the mineral acids. It dissolves in 3 atoms of sulphuric acid to form 2 of the bisulphate, which, on the addition of water is resolved into the tersulphate of alumina, and the insoluble monosulphate.



The same mixture of teracetate of alumina and sulphate of potash, which in a diluted state produces subsulphate of alumina on the application of heat, gives a precipitate of binacetate of alumina when heat is applied to it in a concentrated state. A quantity of sulphate of potash, however, adheres to the insoluble binacetate even after abundant washing.

PRECIPITATE FROM ACETATE OF ALUMINA WITH CHLORIDE OF SODIUM.

A solution of teracetate of alumina was produced from 1 pound of acetate of lead in 10 pounds of water, decomposed by tersulphate of alumina. After purification, common salt was added to it in the proportion of 1 equiv. to 1 of tersulphate of alumina. The solution, when heated in the water-bath, became of an opaque white from the deposition of a powder so very fine that the mixture passed through the filter almost without change. Neither heat, nor any other application could alter this character. It was left at rest, and after some

weeks, the liquid having become nearly clear, was poured off, and the precipitate, which had contracted into $\frac{1}{64}$ of the bulk of the liquid was mixed again with fresh water 11 times its volume. After several weeks more, the precipitate fell again to the bottom of the vessel, when it was mixed with a third portion of fresh water, which again, after four weeks, was decanted, and the precipitate dried in a capsule at 100° Fahr.

On analysis it yielded the following results—I do not give the details of the experiments, not having made out a formula which can be stated in atomic proportions:—

Alumina	44.66
Acetic acid	21.96
Hydrochloric acid . .	5.51
Water	25.90
	98.03
Chloride of sodium . .	1.97
	100.00

Nitrate of potash forms a precipitate when heated with acetate of alumina, similar in appearance to that from common salt, but it was not particularly examined.

CONCLUSIONS.

1. The aluminous solution obtained by decomposing pure tersulphate of alumina with the neutral acetate of lead consists, I believe, of a mixture of binacetate of alumina, with an equivalent of free acetic acid. No true teracetate of alumina appears to exist.

2. When means are taken to evaporate the preceding aluminous solution at a low temperature with sufficient rapidity, a dry substance is obtained, which may be redissolved easily and entirely by water. This is the binacetate of alumina, ($\text{Al}_2\text{O}_3, 2\text{C}_4\text{H}_3\text{O}_3 + 4\text{HO}$), in which the alumina retains all its usual properties.

3. When the first aluminous solution, containing not less than 4 or 5 per cent of alumina, is left for some days in the cold, a salt is deposited in the form of a white crust, which is an allotropic binacetate of alumina, insoluble in water. Heat effects the same change in the aluminous solution more rapidly, and the new acetate then precipitates as a granular powder. At the boiling temperature, the liquid is thus deprived, in about half an hour, of the whole of its alumina, which goes down with two-thirds of the acetic acid; leaving one-third in the liquid.

4. The red acetates of iron treated in a similar manner do not produce corresponding isomeric binacetates. By boiling the binacetate of the sesquioxide there is a total separation of acid and base.

5. The soluble binacetate of alumina is decomposed by heat, and affords a new and remarkable product. When a dilute solution of that salt is exposed to heat for several days, the whole acetic acid appears to become free, and the alumina to pass into an allotropic condition, in which, although it remains in solution, it ceases to be capable of acting as a mordant, or entering into any other definite combination. Indeed alumina in this altered state appears to be truly soluble in pure water. The allotropic alumina retains 2 equivs. of water, when dried at the heat of boiling water. Its solution is coagulated by the mineral, and most of the vegetable acids; by the alkalies; by a great number of neutral salts; and by decoctions of dye-woods.

This alumina is insoluble in the stronger acids, but soluble in acetic acid as well as in pure water, unless it has been previously coagulated by the means above mentioned, when it remains insoluble. It yields, however, to the continued action of boiling potash, which changes it into the ordinary terhydrate. Its coagulum with dye-woods has the colour of the infusion, but is translucent and entirely different from the dense opaque lakes which ordinary alumina forms with the same colouring matters.

6. The insoluble binacetate of alumina, when digested in a large quantity of water, is gradually changed into the soluble binacetate; of which a part, however, becomes decomposed during the process into acetic acid and the allotropic bihydrate of alumina.

7. The precipitate which is formed on the application of heat to a mixed solution of acetate of alumina and sulphate of potash, and which is soluble in cold acetic acid, is a bibasic sulphate of alumina.

NOTICES

OF

PAPERS CONTAINED IN OTHER JOURNALS.

By HENRY WATTS, B.A., F.C.S.

Researches on the Quantities of Heat disengaged in Chemical and Molecular Actions.*

By P. A. Favre and J. T. Silbermann.

PART I.—HEAT DISENGAGED IN RAPID COMBUSTION.

The apparatus in which the combustions were performed, consisted of a vessel of gilt brass plate, immersed in a water-calorimeter of silvered copper-plate. The oxygen gas previously dried, was made to flow into the combustion-chamber; and the gases produced by the combustion, were forced, previous to their exit from the calorimeter, to traverse a spiral tube of thin copper, so that they might be completely cooled down to the temperature of the water in the calorimeter. This water, whose volume was about 2 litres, was kept in constant motion by a peculiar apparatus, and thereby maintained at a constant temperature throughout its whole mass. The calorimeter was surrounded with two similar vessels, the outer interval thus formed being filled with water, and the inner, or that which was next to the calorimeter, with swan-down, whereby the loss of heat by external conduction was reduced to a very small and perfectly constant

* Ann. Ch. Phys. [3], XXXIV, 357; XXXVI, 5; XXXVII, 405; Compt. Rend. XVIII, 695; XX, 1565 and 1734; XXI, 944; XXII, 483, 823, 1140; XXIII, 199, 411; XXIV, 1081; XXVI, 595; XXVII, 56, 111, 158, 362; XXVIII, 627; XXIX, 449; Jahresber. 1847—8, 52, 55; 1849, 23, 27; 1852, 17.

quantity, viz., 0.002° for a difference of 1° C. between the water in the calorimeter and the external water.

Solid bodies were set on fire by the introduction of small pieces of burning charcoal; liquids were burned in small lamps with asbestos-wicks; gases were introduced into the combustion-chamber in jets, previously set on fire; charcoal was disposed in a layer on a sieve-formed bottom, through the openings of which the oxygen had free access to it. In experimenting with many difficultly combustible substances, such as sugar-charcoal, it was necessary, in order to ensure continuous combustion, to add a quantity of wood-charcoal; the heat of combustion of this substance was then deducted from the total result.

The rise of temperature of the water in the calorimeter was read off, at stated intervals measured by a Breguet's chronometer, by means of a cathetometer, which gave the measurements to $\frac{1}{20}$ of a millimeter, whilst a degree of the thermometer attached to the calorimeter, occupied a length of 8 millimeters.

The weight of the substance burnt was determined, when possible, not by direct weighing of the body before and after combustion, but from the weight of the products of combustion.

The following are the results of the investigation. The units are the gramme, and the quantity of heat required to raise the temperature of 1 gm. of water from 0° to 1° C.

1 gm. of Hydrogen in combining with Oxygen evolves	34462 heat-units.
1 " " " Chlorine "	23783 "

Carbon.—As the combustion of carbon in the calorimeter never produced pure carbonic acid and carbonic oxide, it became necessary, first to ascertain the heat of combustion of carbonic oxide, in order to apply the proper corrections to the observations made upon carbon itself. The carbonic oxide was burnt, according to Dulong's process, mixed with hydrogen; the gaseous mixture produced by the combustion was analysed, and the heat of combustion of the hydrogen deducted. The results were as follows:

1 gm. carbonic oxide in combining with oxygen evolves	2403 heat-units.
1 " wood-charcoal " " "	8080 "
1 " sugar-charcoal " " "	8040 "

It is interesting to compare the heat of combustion of different kinds of carbon with their specific heats, as determined by Regnault:

	Heat of Combustion for 1 grm.	Specific heat.
Wood-charcoal	8080.0	0.24150
Coke from gas-retorts . . .	8047.3	0.20360
Native graphite	7796.6	0.20187
Graphite from blast-furnaces .	7762.3	0.19702
Diamond	7770.0	0.14687

From this it appears that the heat of combustion of carbon increases with its specific heat.

Hydrocarbons.—1 grm. marsh-gas evolved 13063 heat-units; compounds of the formula $n(C_2H_2)$ gave the following values:

Olefiant gas	C_4H_4	11858 heat-units.
Amylene	$C_{10}H_{10}$	11491 "
Paramylene	$C_{20}H_{20}$	11303 "
The compound	$C_{22}H_{22}$	11262 "
Cetene	$C_{32}H_{32}$	11078 "
Metamylene	$C_{40}H_{40}$	10928 "

Hence it appears that the heat of combustion diminishes, the oftener the group of atoms C_2H_2 enters into the compound. Favre and Silbermann have constructed a curve which exhibits this decrease to the eye; and, from a comparison of amylene with metamylene, they infer that each addition of C_2H_2 causes a decrease of 37.5 heat-units. Hence the following table:

Compound.	Heat of Comb.	Compound.	Heat of Comb.
20 (C_2H_2)	10928.5	10 (C_2H_2)	11303.5
19 "	10966.0	9 "	11340.0
18 "	11003.5	8 "	11378.5
17 "	11041.0	7 "	11415.0
16 "	11078.5	6 "	11453.5
15 "	11116.0	5 "	11491.0
14 "	11153.5	4 "	11528.5
13 "	11191.0	3 "	11565.0
12 "	11228.5	2 "	11603.5
11 "	11266.0	1 "	11640.0

The difference between the calculated heat of combustion of olefiant gas and that determined by experiment, is explained by the fact that the calculation is based upon data afforded by the combustion of liquids, and consequently, the quantity of heat required to retain the compound in the gaseous state, ought to be added.

Ethers and Alcohols.—Common ether evolved 9027.6 heat-units; amylie ether 10188.

Methyl-alcohol evolved 5307.1; common alcohol 7183.6; amylie alcohol 8958.6; and cetyllic alcohol 10629.2. From these data

the following table is constructed for the various bodies of the series n ($C_2 H_2$) + 2 HO.

Compound.	Heat of Comb.	Compound.	Heat of Comb.
20 ($C_2 H_2$) + 2 HO	11000.0	10 ($C_2 H_2$) + 2 HO	10000.0
19 " "	10910.0	9 " "	9850.0
18 " "	10816.0	8 " "	9680.0
17 " "	10723.0	7 " "	9480.0
16 " "	10629.0	6 " "	9240.0
15 " "	10535.0	5 " "	8958.6
14 " "	10440.0	4 " "	8560.0
13 " "	10345.0	3 " "	8020.0
12 " "	10245.0	2 " "	7184.0
11 " "	10130.0	1 " "	5301.5

1 grm. of acetone evolved in combustion 7303 heat-units.

Fatty acids.—Formic acid evolved 2091, acetic acid, 3505.2, butyric acid 5647.0, valerianic acid 6439.0, cetyllic acid 9316.5, stearic acid 9716.5, and the curve which represents the increase of these numbers agrees with the following table:

Compound.	Heat of Comb.	Compound.	Heat of Comb.
20 ($C_2 H_2$) + O_4	9940	10 ($C_2 H_2$) + O_4	8320
19 " "	9820	9 " "	8060
18 " "	9700	8 " "	7780
17 " "	9560	7 " "	7430
16 " "	9420	6 " "	7000
15 " "	9270	5 " "	6439
14 " "	9130	4 " "	5623
13 " "	8950	3 " "	4670
12 " "	8750	2 " "	3505
11 " "	8530	1 " "	1915

Compound Ethers.—These compounds, which are isomeric with the fatty acids, yielded the following results:

Formiate of methyl . . .	2 ($C_2 H_2$) + O_4	4197.4 heat-units.
Acetate of methyl . . .	3 ($C_2 H_2$) + O_4	5342.0 "
Formiate of ethyl . . .	3 ($C_2 H_2$) + O_4	5278.8 "
Acetate of ethyl . . .	4 ($C_2 H_2$) + O_4	6292.7 "
Butyrate of methyl . . .	5 ($C_2 H_2$) + O_4	6791.5 "
Butyrate of ethyl . . .	6 ($C_2 H_2$) + O_4	7090.9 "
Valerate of methyl . . .	6 ($C_2 H_2$) + O_4	7375.6 "
Valerate of ethyl . . .	7 ($C_2 H_2$) + O_4	7834.0 "
Acetate of amyl . . .	7 ($C_2 H_2$) + O_4	7971.2 "
Valerate of amyl . . .	10 ($C_2 H_2$) + O_4	8543.6 "
Ethylate of cetene . . .	32 ($C_2 H_2$) + O_4	10342.2 "

These numbers show that bodies isomeric in composition, do not

evolve equal quantities of heat in combustion. This conclusion is confirmed by the following numbers :

Compound.	Heat of Combustion.
Terebene $C_{20}H_{16}$	10662
Oil of turpentine . . $C_{20}H_{16}$	10852
Oil of lemons . . . $C_{20}H_{18}$	10959

Hydrate of phenyl evolved 7842·3 heat-units.

Sulphur.—Especial care was devoted to the determination of the heat given out by the combustion of sulphur in its various molecular states. The results were as follows :

	Heat-units.
Sulphur fused seven years before the experiment . . .	2216·8
„ heated to the softening point, three months before the experiment	2213·8
„ crystallized from sulphide of carbon	2225·8
„ crystallized from persulphide of hydrogen . . .	2229·5
Native sulphur from Sicily in fine crystals	2220·9
Mean	2220·5
Melted sulphur, burnt several hours after crystallization .	2260·3
Native opaque sulphur	2249·0
ditto	2274·6
ditto mixed with reddish crystals	2337·1

The difference of 40 units between the heat of combustion of sulphur crystallized a long time before the experiment, and that of sulphur crystallized but short time before, is beyond any possible limit of error, and must therefore be due to the different molecular constitution of the two varieties.

The combustion of sulphide of carbon yielded 3400·5 units, whereas, if the heat of combustion of the elements be separately calculated, as it would be if they were in the uncombined state, the result is 3146·3 units. The heat required to bring the elements into the state in which they can combine, must evidently be greater than that which is evolved in the act of combination.

PART II.—EXAMINATION OF CERTAIN PHENOMENA OF CHEMICAL DECOMPOSITION AND OF MODIFICATIONS BY DIMORPHISM.

It is generally supposed that when the elements of any compound separate from each other, a quantity of heat is absorbed equal to that which was evolved in their combination; and this supposition is confirmed by experience in a great number of instances. Nevertheless, it is not universally true that chemical decomposition is accompanied by absorption of heat; there are bodies which evolve

heat in decomposing. This is shown, for example, in the combustion of charcoal in nitrous oxide.

1 gram. of charcoal burnt in nitrous oxide, evolved 11158 heat-units, considerably more therefore than when burnt in oxygen. Hence it appears that *in the separation of oxygen from nitrogen, heat is not absorbed, but evolved*; and by comparison of the quantities of heat evolved by the combustion of charcoal in oxygen and in nitrous oxide, it appears that in the separation of 1 gram. of oxygen out of nitrous oxide, 1154 units of heat must be evolved.—The authors likewise endeavoured to estimate the quantity of heat evolved in this separation, by decomposing nitrous oxide into nitrogen and oxygen in the calorimeter by the heat of burning charcoal, and deducting the heat of combustion of the charcoal from the total effect observed. By this method they found that 1 gram. of oxygen in separating out of nitrous oxide, evolves 1090.5 heat-units.

Experiments on the separation of oxygen from peroxide of hydrogen by the action of immersed platinum, made in a mercury-calorimeter of peculiar construction (*vide* p. 240), gave for the separation of 1 gram. of oxygen, an evolution of 1303 units as a mean result. The numbers obtained in 5 experiments were 1349, 1264, 1313, and 1288; and the authors are of opinion that the highest number 1349, is nearer to the truth than the mean, because the disengagement of oxygen was very difficult to regulate, and was generally too rapid to allow the gas to give off all its heat to the calorimeter. Moreover, this number, 1349, requires an addition of 14° for the heat rendered latent in the aqueous vapour carried off by the gas. Hence the quantity of heat evolved in the separation of 1 gram. of oxygen from peroxide of hydrogen, is 1363 units.

The decomposition of oxide of silver by heat, gave results which did not agree very well with each other. As a mean result it was found, that in the decomposition of 1 gram. of oxide of silver, 21.1 units of heat were absorbed. As one of the elements assumes the gaseous form, the small absorption of heat would seem to show, that in the separation of oxygen from silver, heat is likewise evolved.

Decomposition of Calcespar and Arragonite.—The experiments were made in the water-calorimeter.

In the decomposition of 1 gram. of calcespar by heat, 308.1 units of heat were *absorbed*.

In the transformation of 1 gram. of calcespar into arragonite, 39.1 units were *evolved*.

In the decomposition of 1 gram. of arragonite, 299.3 units were *absorbed*.

The authors likewise examined by polarized light the course of the transformation of arragonite into calcespar, and found that when a crystal of arragonite is heated, the two poles of the lemniscate seen on examining the crystal by polarized light, gradually approach each other, and the closed curves around each pole also approximate

and open out one after the other, so as to form single curves enclosing both poles; but before the union of the two poles was complete, the crystal became opaque.

PART III.—COMBINATIONS IN THE HUMID WAY.

Most of the experiments to be detailed in the remaining part of this paper were made in a *mercury-calorimeter*. This instrument may be regarded as a thermometer with a very large reservoir of mercury, and capable of receiving within it the bodies by which the heat is evolved or absorbed. It consists of a glass globe of the capacity of about 1 litre, and having three apertures, one at the top and two at the sides. Into one of the lateral apertures is fixed, in a slanting position, a tube of thin iron, or platinum, closed at the bottom; and into this tube, which is called the *muffle*, is introduced another tube of very thin glass containing the substances which are to be submitted to experiment; it is fused into the metal tube by a cork. At the second lateral aperture, the globe is drawn out into a neck which curves vertically upwards, and into the neck is inserted the bent extremity of a horizontal capillary-tube, the use of which is to measure the changes of volume of mercury in the globe. Through the upper aperture of the globe passes a steel piston moved by a screw, for the purpose of bringing the extremity of the mercurial column in the horizontal tube to any desired point. (For the method of graduation we must refer to the memoir).

Hydration of Sulphuric Acid.

The quantities of heat evolved by mixing 1 grm. of sulphuric acid, SO_3 , HO, with various proportions of water are as follows:

Water in equivalents.					Heat-units.	Differences.
With the first	$\frac{1}{8}$	equiv. of water	.	.	9.4	0.6
„ second	$\frac{1}{8}$	„	„	.	8.8	
„ first	$\frac{1}{4}$	„	„	.	18.8	1.6
„ second	$\frac{1}{4}$	„	„	.	17.2	
„ first	$\frac{1}{2}$	„	„	.	36.7	8.4
„ second	$\frac{1}{2}$	„	„	.	28.3	
With 1	equiv. of water	.	.	.	64.7	29.9
„ 2	„	„	.	.	94.6	
„ 3	„	„	.	.	111.9	17.3
„ 4	„	„	.	.	122.2	
„ 5	„	„	.	.	130.7	10.3
„ 6	„	„	.	.	136.2	
„	„	„	.	.	136.2	8.5
„	„	„	.	.	130.7	
„	„	„	.	.	122.2	5.5
„	„	„	.	.	111.9	

Water in equivalents.		Heat-units.	Differences.
With 6 equivs. of water		136.2	5.6
„ 7 „	„	141.8	
„ 8 „	„	145.1	3.3
„ 9 „	„	148.5	
„ 10 „	„	148.4	0.0
„ 20 „	„	148.6	

1 grm. of SO_3 , 2 HO mixed with water evolves :

With the first	$\frac{1}{4}$ equiv. of water	. . .	9.2	1.4
„ second	$\frac{1}{4}$ „	„ . . .	7.8	
„ first	$\frac{1}{2}$ „	„ . . .	17.2	4.9
„ second	$\frac{1}{2}$ „	„ . . .	12.3	

Therefore with 1 equiv. 29.6

1 grm. of SO_3 , 3 HO mixed with water evolves :

With the first	$\frac{1}{2}$ equiv. of water	. . .	9.5	1.9
„ second	$\frac{1}{2}$ „	„ . . .	7.6	

Therefore with 1 equiv. 17.1

In operating on fractions of equivalents of water, the authors' object was to ascertain whether 1 equiv. of water could unite with 1, 2, 3, 4, &c., equivs. of hydrated sulphuric acid in the same manner as 1 equiv. of water combines with 2 equivs. of anhydrous sulphuric acid ; the results just given justify the anticipation.

Heat disengaged by the solution of gases in water :

1 grm. hydrochloric acid gas dissolved in water	evolves	449.6 heat-units.
1 „ hydrobromic „ „ „ „	235.6	„
1 „ hydriodic „ „ „ „	147.7	„
1 „ sulphurous „ „ „ „	120.4	„
1 „ ammoniacal gas „ „ „ „	514.3	„

Solution of Salts in Water.

The following table contains the quantities of heat absorbed (or evolved) in the solution of 1 grm. of certain salts in excess of water. (The numbers marked + denote heat evolved).

Some of the numbers relate to the solubility of salts which in reality are insoluble or but very sparingly soluble in water. This fiction rests upon considerations which will be explained hereafter. When an insoluble compound is formed by the combination of an acid with a base, in presence of water, and the quantity of heat evolved is different from that which is given out in the combination of another acid with the same base, when the compound is a soluble salt, the difference may generally be attributed to the insolubility of the first mentioned product; and it is this difference which may be represented by the fictitious solubility of the salt. The utility of the numbers thus obtained will be seen in the part of the memoir which treats of the interchanges of heat between chemically equivalent masses (pp. 253—258).

Oxides or metals	Sulphates.	Nitrates.	Chlorides.	Bromides.	Iodides.	Phosphates.	Pyro-phosphates.	Oxalates.	Tartrates.	Acetates.	Carbonates.	Sulphides.
Of potash	35.3	70.5	51.9	37.8	29.2	—	—	39.7	17.3	—	—	anhydrous +96.9
Of soda	49.1	45.5	8.9	—	—	52.3	21.9	—	25.2	28.1	52.7	—
Of ammonia	11.1	65.9	65.1	—	—	—	—	—	—	—	—	—
Of lime	24.7	27.1	15.5	—	—	—	—	—	—	3.5	—	—
Of baryta	64.4	—	16.9	—	—	—	—	—	—	—	—	—
Of strontia	—	41.2	24.0	—	—	—	—	—	—	—	—	—
Of zinc	14.8	—	anhydrous +92.2	—	—	—	—	—	—	—	—	—
Of iron (protoxide)	12.1	—	anhydrous +58.3	—	—	—	—	—	—	—	—	—
Of lead	—	14.9	—	—	—	—	—	—	—	14.8	—	—
Of silver	—	81.1	—	—	—	—	—	—	—	—	—	—
Of Uranyl (U ₂ O ₂)	10.7	—	—	—	—	—	—	—	—	—	—	—
Of copper	—	—	bichloride anhydrous +73.7	—	—	—	—	—	—	—	—	—
Of water	—	—	—	—	—	—	—	67.0	19.8	—	—	—
Of potash and water	—	—	—	—	—	—	—	62.1	—	19.3	51.5	—
Of potash and soda	25.6	—	—	—	—	—	—	—	40.0	—	—	—
Of potash and alumina	—	—	—	—	—	—	—	—	—	—	—	—
Of potash and protoxide of iron	23.1	—	—	—	—	—	—	—	—	—	—	—
Of ammonia and alumina	24.5	—	—	—	—	—	—	—	—	—	—	—
	19.0	—	—	—	—	—	—	—	—	—	—	—

Formation of Neutral Salts.

The annexed table exhibits the quantities of heat evolved by the combination of 1 grm. of a base with equivalent quantities of the various acids. The numbers marked with an asterisk are those which represent the mean of experiments made by precipitation; the other numbers relate to the calorific effect of an acid on a base in solution or previously precipitated.

1 Gramme of Oxide of	Acids in Solution.										Acids in the Gaseous State.						
	Sulphuric.	Nitric.	Hydrochloric.	Hydrobromic.	Hydriodic.	Phosphoric. 1-hydrated. 2-hydrated. 3-hydrated.			Formic.	Acetic.	Valerianic.	Citric.	Oxalic.	Tartaric.	Carbonic.	Sulphurous.	Hydrosulphuric.
Potassium	342.2	329.7	333.1	329.9	333.8	344.3	360.2	378.4	—	297.3	—	290.6	301.2	277.5	274.0	409.3	137.8
Sodium	520.1	493.2	492.7	489.1	480.8	496.9	505.2	—	429.3	438.7	—	425.1	443.6	408.1	—	—	211.3
Ammonium	565.0	526.7	520.6	—	—	—	—	—	—	486.5	—	—	—	—	—	—	—
Barium	270.5	202.1	201.4	—	—	—	—	—	—	174.5	—	—	—	—	—	—	—
Strontium	—	—	278.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Calcium	669.8	605.1	606.5	—	—	—	—	—	—	524.1	—	—	—	—	—	—	—
Magnesium	*712.9	—	—	—	—	—	—	—	—	613.5	—	—	—	—	—	—	—
Manganese	*345.1	642.4	661.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Iron (protoxide)	346.2	310.6	320.7	—	—	—	—	—	—	285.2	—	—	—	—	—	—	—
Zinc	*302.5	268.4	273.1	—	—	—	—	—	—	238.6	—	—	—	—	—	—	323.4
Cobalt	*255.2	203.2	202.6	—	—	—	—	—	—	188.3	—	—	—	—	—	—	252.1
Nickel	*309.3	261.6	272.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper (black oxide)	310.4	274.8	273.6	—	—	—	—	—	—	244.1	—	—	—	—	—	—	—
Cadmium	*314.7	—	—	—	—	—	—	—	—	243.3	—	—	—	—	—	—	—
Lead	316.5	159.5	160.4	—	—	—	—	—	—	131.6	—	—	—	—	—	—	474.2
Silver	*193.8	126.7	128.1	—	—	—	—	—	—	117.9	—	—	—	—	—	—	—
Aluminium	194.5	82.5	101.1	99.9	133.9	—	—	—	—	64.0	—	—	—	—	—	—	121.5
Iron (sesquioxide)	*157.2	53.5	197.9	220.4	275.8	—	—	—	—	—	—	—	—	—	—	—	268.4
	160.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	101.9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	89.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	644.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	249.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Protoxides.

13 Oxides.

Acid and Double Salts.

The experiments were made with about 3 decigrammes of potash or soda with 1, 2, or 8 equivs. of acid, in a flask containing 18 cub. cents. of water.

1. Potash with oxalic acid.

1 grm. of potash, diluted with water and saturated with oxalic acid, yielded :

With 1 equiv. of acid	301·2
„ 2 „ „ and a large quantity of water	299·0
„ 2 „ „ and a small quantity of water	367·8
„ 4 „ „ water in flask at 16° . . .	609·4
Full of water at 13°	610·0
„ „ 11°	672·0

2. Soda with oxalic acid.

1 grm. of soda, diluted with water and saturated with oxalic acid, yielded :

With 1 equiv. of acid	443·6
„ 2 „ „ and a large quantity of water	650·3
„ 4 „ „ „ „ „ „	682·7
The flask full of water saturated with acid . . .	739·0

3. Potash with tartaric acid.

grm. of potash, diluted with water and saturated with tartaric acid, yielded :

With 1 equiv. of acid	277·5
„ 2 „ „ and a large quantity of water	476·9
„ 2 „ „ and a small quantity of water	502·4
„ 8 „ „ and a large quantity of water	506·0

4. Soda with tartaric acid.

grm. of soda, diluted with water and saturated with tartaric acid, yielded :

With 1 equiv. of acid	408·1
„ 2 „ „ and a small quantity of water	616·9
„ 4 „ „ and a large quantity of water	411·0
„ 4 „ „ and a small quantity of water	624·9
„ 8 „ „ and a large quantity of water	435·2
„ 8 „ „ and a small quantity of water	618·9

These results appear to show that when a base is mixed with excess of acid in such quantity as not to form a liquid saturated with the resulting acid salt, the quantity of heat evolved corresponds simply to the formation of a neutral salt; but if the liquid is sufficiently concentrated to deposit the first crystals of the acid-salt, a calorific effect is produced which indicates the formation of a new compound. From this it appears probable that an acid may exist in presence of a neutral salt containing the same acid, without combining with it, at all events immediately, as if the molecules offered some resistance to the formation of the new compound. A phenomenon of the same kind appears to be presented by pyrophosphoric and metaphosphoric acid, which, as is well known, may dissolve in excess of water, without immediately passing to the state of $\text{PO}_5, 3 \text{HO}$.

The combination of potash with sulphuric and acetic acid likewise presents results similar to those above detailed with oxalic and tartaric acid. Thus, for 1 gram. of potash treated with—

	Sulphuric acid.	Acetic acid.
An equivalent weight of . . .	332.1	296.0
Twice the equivalent weight . . .	332.9	294.1

Since a neutral salt may remain dissolved in water in presence of an excess of acid without entering into any combination with it appreciable by the calorimeter, it appeared worth while to inquire whether acid salts, of definite constitution in the crystalline state, may not be decomposed by contact with excess of water. The authors experimented with this view on biacetate, bisulphate, and bisulphite of potash; the first of these does not appear to be decomposed; the second appears to be decomposed by a very great excess of water (which it was necessary to use in order to avoid the separation of the sparingly soluble neutral sulphate); but it is doubtful whether it would be decomposed by a large quantity. The bisulphite appears to be decomposed by water.

In the formation of *bicarbonate of potash*, the second equivalent of carbonic acid, on being added to the first, evolves an additional quantity of heat equal to 78.2 units.

Hydrosulphuric acid, in combining with protosulphide of potassium in solution, evolves the same quantity of heat as in uniting with an equivalent quantity of potash to form a protosulphide. Hence the quantity of heat evolved by hydrosulphuric acid in combining with 1 gram. of potash to form the sulphide of hydrogen and potassium is, $137.8 \times 2 = 275.6$ units.

Double Salts.—No heat is evolved on mixing the solutions of:

1. Protosulphate of iron and sulphate of potash;
2. Sulphate of alumina and sulphate of soda;

3. Sulphate of alumina and sulphate of potash ;
4. Sulphate of alumina and sulphate of ammonia ;
5. Tartrate of potash and tartrate of soda ;

provided that the quantity of water present is sufficient to prevent the solution from arriving at the limit of solubility of the double salt. It appears then that, as in the case of acid salts, no calorific effect is produced, so long as the double salt which should be formed, remains in solution.

Basic Salts.—The only salts of this class on which the authors experimented, were the acetates of lead. On precipitating 3 equivs. of neutral acetate of lead by 2 equivs. of potash added successively, it was found that the first equiv. of lead set at liberty, evolved, on combining with the neutral acetate, 20·1 units of heat ; but the second equiv. of oxide of lead, set free by the second equiv. of potash, caused no perceptible evolution of heat. Hence it appears that the third equiv. of lead in the tribasic acetate enters into combination without appreciable development of heat. This result was confirmed by treating 1 equiv. of the tribasic acetate in solution, with 1, 2, and 3 equivs. of sulphuric acid in succession. It was found, taking account of the heat evolved by the combination of the oxide of lead with the sulphuric acid, that

The first equiv. of PbO, in combining with	
acetic acid, evolves	22·8 units.
The second	65·9 „
The third	2·2 „

numbers which accord very nearly with the results obtained by the former method.

Combination of Acids with Anhydrous Bases.

1. *Lime.*—One gramme of lime, treated with dilute hydrochloric acid, evolves 750·4 heat-units ; but 1 grm. of hydrate of lime, in combining with the same acid, evolves 606·5 units ; hence a gramme of lime, in combining with water, evolves $750·4 - 606·5 = 143·9$ units of heat.

Experiments have already been mentioned (p. 239) relating to the heat absorbed in the decomposition of calespar, and to the heat evolved in the disintegration of arragonite. In those experiments the decompositions were effected by the direct action of heat. To ascertain the same quantities in the wet way, the authors decomposed calespar and arragonite with hydrochloric acid.

A quantity of Calespar, containing 1 grm. of lime
evolved, when thus treated 82·7 units.

A quantity of Arragonite, containing 1 grm. of lime 106·3 „

Hence, as 1 grm. of lime, in combining with hydrochloric acid, evolves

750·4 units, it follows that 1 grm. of lime, in combining with carbonic acid, evolves

To form calespar . . . 750·4 — 82·7 = 667·7 units.

To form arragonite . . . 750·4 — 106·3 = 644·1 „

consequently

1 grm. of calespar in forming, evolves . . . 373·5 units.

1 grm. of arragonite 360·6 „

The difference, 12·9, between these numbers, represents the quantity of heat disengaged by 1 grm. of arragonite, in passing to the state of calespar. The quantities given by the former method, were, 308·1 units absorbed in the decomposition of calespar, and 39·1 units evolved in the formation of arragonite. The authors consider the results obtained in the wet way as by far the more trustworthy.

2. *Baryta*.—One gramme of baryta, treated with dilute hydrochloric acid, evolved 392·2 units of heat. Now 1 grm. of hydrate of baryta in solution, evolves in combining with the same acid, 201·4 units. Therefore 1 grm. of baryta, in passing to the state of hydrate, evolves $392·2 - 201·4 = 190·8$ units.

3. *Strontia*.—For strontia the corresponding numbers are : $525·6 - 278·9 = 246·7$ units.

4. *Oxide of Lead*.—One grm. of anhydrous oxide of lead, treated with dilute nitric acid, evolves 85 units of heat ; with acetic acid, 64·1 units ; quantities equal to those evolved by the hydrated oxide, under similar circumstances.

5. *Oxide of Zinc*, obtained by the combustion of zinc in oxygen, evolves with dilute sulphuric acid, 267·8 units ; with dilute hydrochloric acid, 207·1 units.

6. *Oxide of Copper* precipitated from a hot solution by potash, gives with dilute sulphuric acid, 206·6 units ; with dilute nitric acid, 172·1 units.

*Heat produced by the Combination of Metals with Oxygen,
Chlorine, Iodine, &c.*

These determinations were for the most part made by an indirect process, proceeding on the assumption that the heat absorbed in the separation of any two elements, is equal to that which is evolved in their combination. The experiments were made in the mercury-calorimeter.

Chlorine was made to combine with hydrogen in the calorimeter ; the hydrochloric acid produced was absorbed by a large quantity of water, and the product weighed as chloride of silver.

Of the compounds of chlorine with metals, the only one that was formed directly was that with copper. The other metals were either dissolved in dilute hydrochloric acid, or their anhydrous oxides were made to combine with that acid. The second method may, in some

cases, be used as a check on the first; if, however, the metal itself is not attacked by hydrochloric acid, the second method is the only one which can be applied; in both methods the product remains in solution. To obtain the quantity of heat which belongs to the anhydrous product, it is necessary to add the heat which is absorbed by the solution of the compound in water. The heat of combination of bromides and iodides may be obtained in a similar manner; or it may be deduced from that of the corresponding chlorides, by deducting the quantity of heat evolved in the substitution of chlorine for bromine or iodine.

The quantities of heat evolved in the combination of *metals* with *sulphur* may be found in a similar manner, if the quantity evolved in the combination of sulphur with hydrogen has been previously ascertained. The latter was determined from the calorific effect produced by the action of sulphuretted hydrogen gas on sulphurous acid dissolved in water (an action which is represented by the equation: $\text{SO}_2 + \text{Aq} + 2 \text{HS} = 2 \text{HO} + 3 \text{S} + \text{Aq}$). The alkaline sulphides were obtained by the action of hydrosulphuric acid on the dissolved oxides in excess; and the insoluble metallic sulphides by double decomposition between the alkaline sulphides and the salts of the other metals.

The heat evolved by the combination of the different metals with *oxygen* was determined in three ways: 1. By the action of water on the alkali-metals, in which regard must be had to the calorific effects produced by three causes—viz., the combustion of the metals, the combination of the oxides with water, and the decomposition of the water. 2. By dissolving a metal in dilute hydrochloric acid. 3. By precipitating one metal with another. The results are contained in the following tables:

Table I. Formation of oxides:

Anhydrous	{	Zinc . . .	{ 1292.75 heat-units.
		Copper . . .	{ 1289.88 "
		Iron . . .	{ 683.90 "
		Lead . . .	{ 1351.00 "
		Silver . . .	{ 266.11 "
In solution	{	Potassium. . .	{ 56.60 "
		Sodium . . .	{ 1954.81 "
			{ 3196.11 "

Table II. Formation of chlorides:

In solution	{	Potassium. . .	. 2489.54 "
		Sodium . . .	. 4101.15 "
		Zinc . . .	{ 1740.51 "
			{ 1740.80 "
		Copper . . .	. 1078.11 "
		Iron . . .	. 1905.34 "

Anhydrous	{ Lead	430·10	„
	{ Silver	322·12	„

To obtain the quantities of heat evolved in the formation of the anhydrous chlorides of potassium, sodium, &c., the preceding results must be corrected for the quantities of heat evolved or absorbed in the solution of those anhydrous chlorides (see page 242). In that table the results are given for 1 gram. of the chlorides; they must therefore be calculated for 1 gram. of the metal. These corrections being made, we find for the heat evolved in the combination of 1 gram. of the metals with chlorine, so as to form an anhydrous chloride, the following quantities :

Potassium	. 2587·7
Sodium	. 4125·9
Zinc	. 1547·5
Copper	. 922·7
Iron	. 1775·5
Lead	. 430·1
Silver	. 322·2

Table III. Formation of bromides :

	In solution.	Anhydrous.
Hydrogen	28404·00	9332·0
Potassium	{ 2188·30	2303·9
	{ 2196·86	2312·5
Sodium	3592·00	—
Lead	—	315·40
Silver	—	237·19

Table IV. Formation of Iodides :

	In solution.	Anhydrous.
Hydrogen	15004·22	3606·00 absorbed
Potassium	{ 1850·50	1973·20 evolved
	{ 1858·50	1981·20 „
Sodium	3006·20	—
Lead	—	223·15
Silver	—	172·70

Table V. Formation of sulphides :

	In solution.	Anhydrous.
Hydrogen	—	2741·00
Potassium	1306·90	1170·80
Sodium	2101·74	—
Zinc	—	644·31
Iron	—	634·02

	In solution.	Anhydrous.
Copper	—	285·40
Lead	—	91·88
Silver	—	51·15

Formation of Ammonia.—By the action of chlorine on a solution of ammonia, it was found that 1 grm. of hydrogen in combining with nitrogen to form ammonia, evolves 10488·1 heat-units when the ammonia is in solution, and 7576·00 when the ammonia remains in the state of gas.

SPECIFIC AND LATENT HEATS.

The authors have determined, by means of their mercury-calorimeter, the specific and latent heats of various bodies. The specific heats relate to a mean between the boiling-point of the substance and the final temperature of the calorimeter, which differed but little from that of the surrounding air. The following table contains the principal results. The numbers relate to 1 grm. of the substance.

	Specific heat.	Latent heat of vapour.
Water	—	535·77 units.
Bicarbide of hydrogen, from amylic alcohol, boiling be- tween 200° and 210° . . . }	0·49385 (from 20° to 200°)	59·91 (at 205°) "
Bicarbide of hydrogen, from amylic alcohol, boiling be- tween 240° and 260° . . . }	0·49680 (from 20° to 240°)	59·71 (at 250°) "
Methylic alcohol	0·6713	263·86 "
Common alcohol	0·6438	208·92 "
Amylic alcohol	0·5873	131·37 "
Cetylic alcohol	0·5059	58·48 "
Latent heat of liquid		29·31 "
Common ether	0·50342	91·11 "
Acetate of ethyl	0·48344	105·796 "
Butyrate of methyl	0·49176	87·322 "
Essence of turpentine	0·46727	68·734 "
Sulphurous acid	—	94·560 "

For iodine the following results were obtained :

Latent heat of vapour	23·95	units.
Heat given off by liquid iodine from 180° to 107° }	7·90	"
Latent heat of fusion	11·71	"
Heat given off by solid iodine from 107° to 20° (Regnault). . . . }	4·71	"
Specific heat of liquid iodine	0·10822	"
" " solid "	0·05412	" (Regnault).

HEAT EVOLVED IN THE CONDENSATION OF GASES BY POROUS BODIES.

The experiments were made with wood-charcoal, previously washed with hydrochloric acid, and then strongly ignited. The charcoal was introduced into a small flask provided with a stop-cock, exhausted of air, and enclosed in the calorimeter, and the gas was passed over it from a gasometer. The following results were obtained for 1 gm. of the gases condensed by charcoal :

Hydrochloric acid gas evolves	232.5 heat-units.
Sulphurous " " " 	139.9 "
Carbonic " " " 	129.6 "

The quantities of the gases absorbed were also determined, and it was found that 1 gm. of charcoal absorbs of :

Hydrochloric acid gas	69.2 cub. cent.
Sulphurous " " 	83.2 "
Carbonic " " 	45.2 "

HEAT EVOLVED OR ABSORBED BY THE SUDDEN COMPRESSION OR EXPANSION OF VARIOUS GASES.

The heat evolved by the sudden compression of gases is intimately related to their specific heat. In fact, the specific heat of a gas under a constant volume is connected with its specific heat under a constant pressure by the quantity of heat set in motion by the sudden compression or expansion of a given fraction of the original volume, $\frac{1}{27.8}$ for example, which is the expansion or contraction corresponding to 1° of temperature.

Dulong has determined the ratio between the two specific heats of various gases from the velocity of sound in those gases, according to the well-known formula of Laplace :

$$\frac{c}{c'} = \frac{v^2}{\frac{gh}{D} (1 + 00365 \times t)}.$$

From these results, and from the numbers obtained by Delaroche and Bérard for the specific heats of gases under constant pressure, Dulong concludes that: *When equal volumes of different gases, taken at the same temperature and under the same pressure, are suddenly compressed or expanded by the same fraction of their primitive volume, they evolve or absorb the same quantity of heat. The resulting variations of temperature are in the inverse ratio of the specific heats for a constant volume*

It appears, indeed, from the experiments of Delarive and Marcet, as well as from those of Delaroche and Bérard, that all the simple gases have equal specific heats when they are compared in equal

volumes, and Dulong's experiments show that for these gases the ratio $\frac{c}{c'}$ is exactly the same. It follows, therefore, that all simple gases, when equally compressed, experience the same rise of temperature.

With respect to other gases it appears, according to existing data, that *the rise of temperature produced in compound gases, when compressed to the same amount, is less as their specific heat is greater.* We are thus led to inquire whether these differences of temperature proceed *entirely* from the difference of calorific capacity in the compound gases.

The exact determination of the calorific effect produced by the sudden compression and expansion of gases is therefore an object of considerable interest; but hitherto the method adopted in these determinations have been very imperfect.

The apparatus used by Favre and Silbermann, consists of a copper pump-barrel, the lower part of which is lined with glass, so that apertures may be made in the copper (without allowing any escape of gas) in order to observe the variations of a Breguet's thermometer placed inside. Pressure is exerted by a solid piston, the rod of which is moved by a lever connected with the rod by a Watt's parallelogram. The course of the piston is limited to parts proportional to the capacity of the cylinder, by projections which stop the motion of the lever. The gases are introduced into the cylinder by two tubes, the one furnished with a stop-cock and soldered into the lower part of the cylinder, the other entering just under the piston when it is at the top of its course.

In the following table, the temperatures inscribed in the several columns are perhaps too low, because the mass of the Breguet's thermometer is very great in comparison with that of the gas which heats or cools it.

The authors propose, in future researches, to eliminate this cause of error by using several Breguet's thermometers having all the same surface but very different masses. The differences in their indications may then, perhaps, furnish a correction by which the numbers in the following table may be reduced to the values which they would have if the mass of the thermometer were infinitely small. It may be useful also to prevent the reflection of the heat at the surface of the thermometer by coating it with lamp-black.

In the following table, the sign + corresponds to a compression (C), and the sign - to a dilatation (D), for the same horizontal line of temperature :

TABLE OF THE THERMOMETRIC RESULTS PRODUCED BY SUDDEN CHANGE OF VOLUME IN GASES.

Order of combustibility.	Gases.						Variation of temperature for $\frac{1}{2}$ and $\frac{1}{2}$ atmosphere.	Variation of temperature for $\frac{1}{2}$ and 1 atmosphere.	Variation of temperature for $\frac{1}{2}$ and 2 atmosphere.	According to Dulong.		
		Between $\frac{1}{2}$ atmosphere and $\frac{1}{2}$	Between $\frac{1}{2}$ atmosphere and 1	Between 1 atmosphere and 2	Between $\frac{1}{2}$ and 2	Between $\frac{1}{2}$ and 2				Specific heat for constant volume.	Ratio $\frac{c}{c'}$ of the two specific heats.	Variation of temperature for a change of volume $= \frac{1}{2} \frac{1}{2}$
2	Air . . C	+5.6	8.8	13.2	22.0	27.6	0.0204	0.0321	0.0482	1	1.421	0.421
	D	-5.0	7.6	12.8	20.4	25.4						
3	Oxygen . C	+5.6	9.3	13.2	22.5	28.1	0.0204	0.0339	0.0482	1	1.415	0.421
	D	-4.7	7.6	13.2	20.8	25.5						
1	Hydrogen C	+9.7	13.8	18.5	32.3	42.0	0.0354	0.0504	0.0675	1	0.407	0.421
	D	-5.0	8.5	13.7	22.2	27.2						
6	Carbonic acid . C	+4.7	7.3	11.3	18.6	23.3	0.0171	0.0267	0.0412	1.249	0.338	0.337
	D	-4.7	7.3	11.3	28.6	23.3						
4	Carbonic oxide . C	+5.6	8.6	12.6	21.2	26.8	0.0204	0.0314	0.0460	1	1.428	0.423
	D	-5.0	7.3	12.6	19.9	24.8						
5	Nitrous oxide . C	+4.7	6.6	11.0	17.6	22.3	0.0171	0.0241	0.0401	1.227	1.343	0.343
	D	-4.8	6.6	11.3	17.9	22.7						

The numbers in the fourth column of figures in this table are the sum of those in the second and third. They comprise the changes of volume from $\frac{1}{2}$ to 2 atmospheres. The numbers in the fifth column are the sum of the numbers in the first three columns; they therefore comprise the changes of volume from $\frac{1}{4}$ to 2 atmospheres. The authors have ascertained by experiments of verification, that the effect of several successive compressions may be added together without introducing any error into the final result.

It will be seen, that the heat produced by the compression of air and the cold produced by its expansion, are not apparently equal. The same is true for all the other gases, being most conspicuous in case of hydrogen. The difference is due to the various degrees of conducting power of the different gases for heat.

The conducting power of a gas may be regarded as greater or less in proportion to the difference between the amounts of elevation and depression of temperature due to the contraction and expansion. The conducting power of hydrogen appears to exceed that of all other gases as much as that of metals surpasses that of earthy substances. This property of hydrogen appears to account for the rapid cooling of ignited bodies immersed in it, as observed by Andrews and Grove.

The table likewise shows that the elevations of temperature of the compressed gases are nearly in the ratios given by Dulong for each of the gases. Hydrogen deviates from this law, in consequence of its great conducting power.

But the same agreement does not exist with regard to the *absolute* elevations of temperature for each gas referred to a variation of $\frac{1}{27.8}$ of the original volume, and compared with the corresponding numbers calculated by Dulong from his experiments on the co-efficient $\frac{c}{c}$, and the numbers obtained by Delaroche and Bérard for the specific heats of gases under constant pressure. This difference arises from the cause already noticed, viz., the diminution in the rise of temperature caused by the mass of the thermometer.

PART IV.—CALORIFIC EQUIVALENTS.

In the preceding parts of this Memoir, the quantities of heat evolved in chemical combinations have been referred to the unit of weight of one of the combining bodies. More simple and comparable results are, however, obtained by referring them, as we shall now do, to masses proportional to the chemical equivalents of the bodies concerned.

From the data obtained in the third part of these researches (*vide* Table, p. 243), we may form the following table, in which each number represents the sum of the units of heat evolved by a binary compound formed in equivalent proportions, the weight of the equivalent of hydrogen being supposed to be 1 grm. These numbers may be called "Calorific Equivalents;" they represent the heat evolved by the equivalent weight of the resulting compound:

Metals.	Oxides.	Chlorides.	Bromides.	Iodides.	Sulphides.
Hydrogen . .	34462	23783	9322	3606	2741
Potassium . .	—	100960	90188	77268	45638
Sodium . . .	—	94847	—	—	—
Zinc	42451	50296	—	—	20940
Iron	37828	49651	—	—	17753
Copper . . .	21885	29524	—	—	9133
Lead	27675	44730	32802	23208	9556
Silver	6113	24800	25618	18651	5524

These numbers seem to show that the most stable compounds are those whose formation is attended with the greatest evolution of heat.

In order, however, to discuss the relations which may be deduced from a comparison of the calorific equivalents of different compounds, it is necessary to consider these compounds in the state of solution. For the solid state of compounds does not exhibit comparable conditions. We do not know how the heat of combination is effected by the crystalline form which a body assumes, or by its state of

cohesion. Everything, in short, tends to show that the conditions of comparability are realized only when the bodies are in the state of solution.

In fact, whatever bromide or iodide, for example, may exist in solution, the quantity of heat evolved by treating it with chlorine is always the same; similarly, when one metal is substituted for another, whatever may be the soluble compound of which it forms part, as among those contained in the following table.

TABLE OF THE CALORIFIC EQUIVALENTS OF BINARY COMPOUNDS
IN THE STATE OF SOLUTION.

Metals.	Oxides.	Chlo- rides.	Bro- mides.	Iodides.	Sul- phides.	Moduli of metals compared with Po- tassium.	Modulus of each metal compared with the preceding
Hydrogen . .	—	40191	28484	15004	—	— 5726	—
Potassium . .	76238	97091	85678	72479	50969	—	+ 57216
Sodium . . .	73510	94326	82616	69143	48340	— 2724	— 2724
Zinc	—	56567	—	—	—	— 40524	— 37759
Iron	—	53350	—	—	—	— 43741	— 3217
Copper . . .	—	34500	—	—	—	— 62591	— 18850
Moduli of Metal- loids compared with Oxygen .	—	+ 20834	+ 9273	— 4063	— 25219	—	—
Moduli of Metal- loids compared with Chlorine .	—	—	— 11637	— 24994	—	—	—

A glance at the preceding table, will show that all the calorific equivalents of the compounds in any one vertical column differ from those of the corresponding compounds in the other columns, by a constant quantity, which may be called the *Modulus of the Metalloids*; it denotes the quantity to be added or subtracted, in order to pass from the calorific equivalent of an oxide, for example, to the calorific equivalent of the corresponding chloride, bromide, &c.

Also that the calorific equivalents of compounds placed on the same horizontal line, differ from the calorific equivalents of the corresponding quantities on any other horizontal line, by a constant quantity, which may be called the *Modulus* of the calorific equivalents of the *Metals*.

The sign — placed before a certain modulus denotes that the calorific equivalents of compounds containing the element assumed as the term of comparison must be subtracted; the sign + indicates that they must be added.

If the state of solution brings the various binary compounds above mentioned to a comparable state, the question is much simplified;

for, if we would ascertain the difference introduced by each metal united to the same metalloïd, it is sufficient to select the soluble binary compounds. On the other hand, if the same metal is combined with several metalloïds, so as to form soluble compounds, the difference caused by each metalloïd will also be known.

It follows, from the experiments above detailed, that nitric, hydrochloric, hydrobromic and hydriodic acid, in combining with the same base, soluble or insoluble, and forming soluble salts, evolve equal quantities of heat. This law we shall generalize, and say that to attribute theoretically to the formation of an insoluble salt the number which would represent its calorific equivalent, apart from its insolubility, it is sufficient to assign to it the same number that would be given by nitric acid, in the formation of a really soluble nitrate with the base in question. The difference between this theoretical number and the real number arises merely from the insolubility.

The following table contains the calorific equivalents of binary compounds, either actually or hypothetically soluble. The numbers followed by a T, are calculated theoretically, according to the conventions above explained :

Metals.	Oxides.	Chlorides.	Bromides.	Iodides.	Sulphides.
Hydrogen	—	40192	28404	15004	—6247 T
Potassium	76238	97091	85678	72479	50969
Sodium . .	73510	94326	82616	69143	48340
Zinc . . .	35751 T	56567	44857 T	31384 T	10581 T
Iron . . .	32554 T	53350	41640 T	28167 T	7364 T
Copper . .	13684 T	34500	22790 T	9317 T	—11486 T
Lead . . .	21808 T	42661 T	31243 T	18049 T	—3461 T
Silver . . .	—2808 T	18049 T	6636 T	—6563 T	—28073 T

By subtracting the numbers in this table from those in the last but one, we obtain differences which represent theoretically the quantity of heat absorbed by the solution of the compounds in question.

To bring these compounds theoretically to the soluble state, is to ascertain the part of the calorific effect due to the change of state.

HEAT ABSORBED IN THE HYPOTHETICAL SOLUTION OF THE FOLLOWING COMPOUNDS.

Metals.	Oxides.	Chlorides.	Bromides.	Iodides.	Sulphides.
Hydrogen . . .	—	—	—	—	8988
Zinc	6700	—	—	—	10359
Iron	5274	—	—	—	10388
Copper . . .	8201	—	—	—	20619
Lead	5867	2069	1554	5159	13017
Silver	8991	16751	18982	25214	33597

If we now examine the relation between the heat evolved and the energy of the chemical affinities, the metalloïds above considered must be placed in the following order, according to the compounds of each metalloïd with the same metal: *Chlorine, Bromine, Oxygen, Iodine, Sulphur*.

And the metals will be arranged in the following order, which will be the same whether we consider the series of the oxides, chlorides, bromides, iodides or sulphides: *Potassium, Sodium, Zinc, Iron, Lead, Copper, Silver*.

This order agrees tolerably well with that which would be deduced from a general view of the chemical reactions of these metals and the stability of the compounds formed.

Saline Compounds.—Let us now endeavour to institute a comparison between the quantities of heat evolved by the equivalent weights of various bases in combining with 1 equiv. of the same acid. The table may be formed from the soluble sulphates.

Bases, with 1 equiv. of oxygen (MO).	Equivalents of the bases (H=1 grm).	Units of Heat evolved by the equivalent of each base in combining with 40 grms. of real sulphuric acid, or 1 equiv.
Potash	47 grms.	16083
Soda	31 „	15810
Oxide of ammonium . .	26 „	14690
Magnesia	20 „	14440
Oxide of manganese . .	35 „	12075
„ nickel	38 „	11932
„ cobalt	38 „	11780
„ iron	36 „	10872
„ zinc	41 „	10455
„ cadmium	64 „	10240
„ copper	40 „	7720

Bases (M_2O_3).

Sesquioxide of aluminum .	$AlO_{\frac{3}{2}}=17$	10948
„ iron (or oxide) } of <i>Ferricum</i> ? . . . }	$FeO_{\frac{3}{2}}=27$	6736

These numbers indicate a sufficiently close connection between the energy of the affinities of the various bases for the same acid, or the degree of stability of the compound formed, and the quantities of heat disengaged in the act of combination, these quantities of heat being referred to weights of the various bodies proportional to their chemical equivalents.

Those bases which form insoluble sulphates are not included in the table. In this case, the phenomena are no longer comparable, and the numbers which they would give would be too high.

The following table relates to *Nitrates* formed in presence of excess of water.

Bases of the formula MO.	Equivalents of the bases (H = 1 gm).	Units of Heat evolved by an equivalent of each base in combining with 54 grms. of nitric acid.
Oxide of calcium	28 grms.	16943
„ strontium	58 „	16943
„ barium	76 „	15360
„ potassium	47 „	15510
„ sodium	31 „	15283
„ ammonium	26 „	13676
„ magnesium	20 „	12840
„ manganese	35 „	10850
„ nickel	38 „	10450
„ cobalt	38 „	9056
„ iron	36 „	9648
„ lead	112 „	9240
„ zinc	41 „	8323
„ cadmium	61 „	8116
„ copper	40 „	6400
„ silver	116 „	6206

The bases of this table follow one another in the same order, with regard to the heat evolved, as those of the preceding table, which relates to sulphuric acid.

Magnesia and ammonia are tolerably near each other; the oxides of manganese, nickel and cobalt, evolve quantities of heat which are sensibly equal. Oxide of lead, which saturates acids much more completely than the other oxides of the same class, evolves much more heat than oxide of copper.

Sulphuric and phosphoric acid, in combining with bases, evolve more heat than nitric, hydrochloric, hydrobromic and hydriodic acid. Of the three varieties of phosphoric acid, the monohydrated acid evolves the smallest and the terhydrated the largest quantity of heat.

Among the organic acids, oxalic, formic, acetic, valerianic, and citric acids evolve about equal quantities of heat, but less than the mineral acids just mentioned. Lastly, tartaric, carbonic, and hydro-sulphuric acid evolve less heat than any other acids. All these peculiarities will be clearly seen by inspection of the following table, the numbers in which express the quantities of heat evolved in the

combination of various acids with bases in equivalent quantities. The table includes only soluble compounds.

Basic Protoxides.	Acids.															
	Sulphuric.	Nitric.	Hydrochloric.	Hydrobromic.	Hydroiodic.	Phosphoric.			Formic.	Acetic.	lactic.	Citric.	Oxalic.	Tartaric.	Carbonic.	Hydro-sulphuric.
						HO	2 HO	3 HO								
Potash .	16083	15510	15656	15510	15698	16168	16920	17766	—	13973	—	13658	14156	13425	12878	6477
Soda . .	15810	15283	15128	15159	15097	15407	15655	—	13308	13600	13500	13178	13752	12651	—	6550
Oxide of am- mo- nium .	14696	13676	13536	—	—	—	—	—	—	12649	—	—	—	—	—	—
Magnesia .	14440	12840	13220	—	—	—	—	—	—	12270	—	—	—	—	—	—
Oxide of manganese	12075	10850	11235	—	—	—	—	—	—	9982	—	—	—	—	—	—
Oxide of nickel .	11932	10450	10412	—	—	—	—	—	—	9245	—	—	—	—	—	—
Oxide of cobalt .	11780	9956	10374	—	—	—	—	—	—	9272	—	—	—	—	—	—
Oxide of iron . .	10872	9648	9828	—	—	—	—	—	—	8590	—	—	—	—	—	—
Oxide of zinc . .	10455	8323	8307	—	—	—	—	—	—	7720	—	—	—	—	—	—
Oxide of cadmium	10240	8116	8109	—	—	—	—	—	—	7546	—	—	—	—	—	—
Oxide of copper .	7720	6400	6416	—	—	—	—	—	—	5264	—	—	—	—	—	—

PART V.—CHEMICAL ACTION OF THE SOLAR RAYS.

Draper has shown that chlorine, which has been *insolated*—that is, exposed to the direct rays of the sun—will afterwards combine with hydrogen in the dark.

Favre and Silbermann were induced by this result to examine further the modifications produced in chlorine by the action of the solar rays. They have found :

1. That the heat evolved by the action of previously insolated chlorine on caustic potash, is greater than that evolved by the action of non-insolated chlorine, the action in both cases taking place in perfect darkness. 1 grm. of chlorine acting on a concentrated solution of caustic potash, evolves the following quantities of heat :

<i>Insolated</i> chlorine	478·85	units of heat.
Chlorine not <i>insolated</i>	439·70	„
Difference	39·15	„

The authors have also examined the effect produced on a mixture of chlorine and hydrogen, by the various parts of the solar spectrum. Fifty small tubes filled with the mixture, and standing over water, were placed close together in a row, and exposed to a Fraunhofer's spectrum, projected horizontally. By this arrangement each tube was exposed to the action of a single colour. It was found that, in the morning, with a white sky, the maximum

effect was produced towards the fixed line H; in the middle of the day towards G; the maximum effect for the whole day was likewise towards that part; in the evening towards F. The relative effects in the different parts of the spectrum are represented by curves, for which we must refer to the Memoir.

QUANTITIES OF HEAT EVOLVED IN CHEMICAL ACTIONS PRODUCED
BY THE ELECTRIC CURRENT.

The result of the authors' experiments on this subject, are comprised in the three following propositions:

1. The time required for the decomposition of a given weight of water, is proportional to the intensity of the current.

2. Those parts of a given circuit which offer equal resistance to the current, evolve equal quantities of heat.

3. When a voltameter and a platinum wire offering equal resistance to the current, are placed in the same circuit, the quantities of heat evolved by the two are equal, provided the heat absorbed by the decomposition of the water is taken into account.

Researches on Didymium and its principal compounds.

By C. Marignac.*

This paper is a continuation of the author's researches on the cerium-metals. In a former Memoir,† he has treated of the separation of the oxides of the three allied metals, and determined the atomic weights of cerium and lanthanum, and approximately that of didymium. To obtain pure oxide of cerium, he treats the mixture of the three oxides, first with very dilute and then with stronger nitric acid, which latter extracts the last traces of lanthanum and didymium. The oxides of the latter metals can also be obtained quite free from cerium by evaporating to dryness the solution obtained with dilute nitric acid, igniting the residue, and again treating it with nitric acid diluted with at least two hundred times its weight of water.—The oxides of lanthanum and didymium were separated one from the other, by Mosander's method, viz., by dissolving the mixed sulphates to saturation in water at 5° or 6° C., and heating the solution to about 30°, whereupon sulphate of lanthanum crystallizes out, while the greater part of the sulphate of didymium remains in solution. By repeated application of this treatment, the sulphate of lanthanum may be

* Ann. Ch. Phys. [3] XXXVIII, 148.

† Ibid. XXVII, 209.

obtained pure and colourless; and the sulphate of didymium, separated as above from the greater part of the lanthanum-salt, may be further purified by crystallizing, picking out the darkest coloured crystals, recrystallizing these, and repeating this process several times. In the present Memoir, the author adds that the separation of lanthanum and didymium may be considerably facilitated by first dissolving the oxides in a large excess of nitric acid, and precipitating in several successive portions by oxalic acid; the first precipitates thus formed, are of a much deeper rose-colour and much richer in didymium than the latter. The separation thus effected is very imperfect in itself, but it greatly facilitates the subsequent separation of the sulphates, which is much more rapid when one of the oxides is already in great excess with regard to the other.

The atomic weights of the three metals are determined by ascertaining the quantity of chloride of barium required to decompose a given weight of the sulphates. In this manner the author, in his former Memoir, estimated the atomic weight of cerium at 47.26; that of lanthanum at 47.04; and that of didymium at 49.4.—In the present Memoir he returns to the consideration of the atomic weight of didymium, and states that from trials which he has made of the determination of the atomic weights of other oxides by the same method, he finds that it can never be entirely depended upon, because, in most cases, when a sulphate is precipitated by chloride of barium, the precipitated sulphate of baryta, *even when a large excess of chloride of barium is used*, carries down with it a very sensible portion of the soluble sulphate, and retains it in spite of repeated washing. On applying to his former results, a correction on account of this error, he finds the atomic weight of didymium to be = 47.95.

To check this result, another method was used, viz., the precipitation of a solution of the sulphate by oxalate of ammonia. The oxalate of didymium is completely insoluble in a neutral liquid; it washes easily, and does not retain any sulphuric acid. To convert it into protoxide of didymium, it is first roasted, and then strongly ignited by a powerful lamp, or still better, in a furnace, in order to convert the peroxide of didymium into protoxide. This method gives for the atomic weight of the metal, the number 47.85.

Lastly, the atomic weight was determined by the analysis of the chloride. The author found it impossible to obtain a correct result by weighing a portion of the chloride, and determining the chlorine therein, because a solution of the chloride, when evaporated to dryness, gives off a considerable quantity of hydrochloric acid, and leaves a residue partly insoluble in water, the insoluble portion being probably an oxychloride; he therefore, without weighing the chloride, precipitated the chlorine by nitrate of silver, the excess of silver by hydrochloric acid, and then the oxide of didymium by oxalate

of ammonia. A comparison of the weights of the chloride of silver, and oxide of didymium obtained, gave for the atomic weight of the latter, in three experiments, the numbers, 56.26, 55.91, and 55.86, the mean of which is 56.01.

From a comparison of all these results, the author adopts for the oxide the number 56, and consequently for the metal, 48.

The author next proceeds to examine the properties of didymium and of some of its compounds.

Metallic Didymium.—The metal was prepared by heating potassium with an excess of chloride of didymium, in a porcelain tube closed at one end, the chloride having been previously fused with sal-ammoniac. The product was scoriaceous, rather than fused, although it had been subjected to tolerably strong ignition; cold water extracted from it, chloride of potassium and chloride of didymium, and left a greyish pulverulent substance, from which bubbles of hydrogen continually escaped. This residue consisted partly of a grey metallic powder, and partly of a greyish-white crystalline powder, probably oxychloride of didymium. The latter was partially removed by levigation, but the grey powder was not obtained sufficiently pure to take its density. When thrown into an alcohol flame, each metallic particle produced a bright spark like those which accompany the combustion of iron in oxygen. In one of these experiments, there were found in the midst of the pulverulent mass, two small metallic granules, which had probably fused at the first instant of the action of the potassium on the chloride of didymium; they were of an iron-grey colour, with considerable lustre on the fractured surfaces, which however soon tarnished; they flattened a little under the hammer, but soon afterwards broke to pieces. One of these fragments, heated on charcoal before the blow-pipe, did not melt, but after a while was converted into a friable mass of oxide, without having exhibited any particular phenomenon of combustion. These metallic fragments did not appear to decompose water in the cold, but on the following day they were found to be converted into a flocculent mass of oxide, perhaps by the influence of atmospheric oxygen. It appears then that didymium decomposes water at ordinary temperatures when it is in the state of powder, but not after it has been fused. In either case, the addition of an acid instantly gives rise to rapid evolution of hydrogen.

Protoxide.—There appears to be but one oxide of didymium capable of acting as a base, the peroxide giving off oxygen before it dissolves in acids. The protoxide is readily obtained by calcining the nitrate, oxalate, carbonate, or the hydrate precipitated by caustic alkalis. It is brown only when mixed with peroxide; strong ignition renders it perfectly white. Hydrogen has no action upon it at

a red heat, and does not alter its whiteness. When once brought by strong ignition to the state of pure protoxide, it does not become peroxidized, or turn brown by moderate ignition in contact with the air, not even by fusion with nitre; but if a little nitric acid be added to it, and the calcination repeated, the oxide assumes a dark brown colour, which disappears by a stronger calcination.

Protoxide of didymium is a very strong base, but little inferior in this respect to oxide of lanthanum; even after very strong ignition, it dissolves with the utmost facility in the weakest acids, with considerable rise of temperature, and without giving off any gas. It dissolves also in ammoniacal salts at a boiling heat, expelling the ammonia. It rapidly absorbs carbonic acid from the air. Water, with the aid of heat, gradually converts it into a hydrate; but the conversion is not complete till after the lapse of two or three days.

The hydrated oxide precipitated from a solution of the chloride by potash or ammonia, is gelatinous and resembles alumina, but has a very pale rose colour. It is almost impossible to free it completely from chlorine by washing; but the quantity which remains is too small to constitute a basic salt. The hydrate contracts much by desiccation, and assumes a greyish-rose tint. After being dried, first *in vacuo*, and then in a stove at 100° , it loses by strong calcination 15 per cent of its weight. Hence it contains 1 atom of water:

DiO	.	.	56	86.15
HO	.	.	9	13.85
DiO, HO.	.	.	65	100.00

It had probably absorbed a small quantity of carbonic acid during desiccation.

The salts of didymium have generally a pure rose colour, like the sulphate, or slightly violet, like the nitrate in a state of strong solution. Caustic alkalies added to the solutions throw down the gelatinous hydrate; the alkaline carbonates and bicarbonates throw down carbonate of didymium completely insoluble in an excess of these reagents; hydrosulphate of ammonia likewise precipitates the hydrate. Carbonate of baryta precipitates oxide of didymium from its salts, slowly but completely, even without the aid of heat. Oxalate of ammonia also throws it down completely from neutral solutions; even oxalic acid precipitates it almost completely, provided the solution does not contain a great excess of a strong acid. The sulphates of potash, soda and ammonia form, immediately in concentrated solutions, and after some time in dilute solutions, rose-white precipitates of double sulphates, slightly soluble in water, and less soluble in an excess of the reagent, but not perfectly insoluble therein; the sodium-salt is the least soluble of the three. Phosphoric and arsenic acids at a boiling heat form precipitates sparingly soluble in acids.

Before the blow-pipe, oxide of didymium imparts to borax and phosphorus-salt a very pale rose colour, like that produced by a very small quantity of oxide of manganese. It does not colour carbonate of soda.

Peroxide.—When oxide of didymium has not been very strongly ignited, it exhibits a reddish-brown colour more or less deep. It is then in the state of peroxide, dissolves in oxygen-acids with evolution of oxygen, and in hydrochloric acid with evolution of chlorine. It dissolves, however, in these acids, even when extremely dilute, absorbs carbonic acid from the air, and expels ammonia from its salts like the protoxide. It is likewise ultimately converted into hydrate by boiling with water; but the change does not become perceptible for several hours.

This oxide may be obtained by roasting the oxalate or the carbonate; but when thus prepared, it always retains carbonic acid, the carbonate requiring strong ignition to decompose it completely. The peroxide may be more conveniently prepared by calcining the nitrate.

This brown oxide does not appear to be a definite compound, the excess of oxygen in it being small and variable, amounting in different preparations to 0·32, 0·49, 0·53, 0·51 and 0·88 per cent. It is probably a mixture of the protoxide with a peroxide of definite composition. It is so easily attacked by acids, that when it is mixed with carbonate, the latter is the last dissolved.

Sulphide.—When protoxide of didymium is calcined with carbonate of soda and excess of sulphur, and the fused mass digested in water, there remains a greyish-white insoluble residue, which, after desiccation *in vacuo*, suffers no loss of weight by ignition in a current of hydrogen.

It dissolves completely in dilute hydrochloric acid, giving off a small quantity of sulphuretted hydrogen. It is not so quickly attacked as the oxide, and does not appear to be separated by this treatment into 2 parts which dissolve one after the other.

Analysis shows it to be, not a sulphide, but an oxysulphide containing 1 atom of sulphide to 2 atoms of oxide:

				Calculated.	Found.	
3 Di	.	.	.	144	81·82	80·58
2 O	.	.	.	16	9·09	—
S	.	.	.	16	9·09	9·39
2 DiO, DiS	.	.	.	176	100·00	8·50

The pure sulphide of didymium is obtained by passing the vapour of sulphide of carbon carried forward by a stream of hydrogen, over oxide of didymium heated to redness in a porcelain tube. Prepared in this manner, the sulphide does not form a fused mass, but a powder of a light brownish-green colour. When moistened with water, it

exhales an odour of sulphuretted hydrogen, without however giving off bubbles of the gas when immersed in water; it does not dissolve in water. Acids, even when very dilute, decompose it with evolution of sulphuretted hydrogen. Heated on platinum-foil, it becomes ignited like protoxide of tin, and is converted into oxide mixed with subsulphate.

2·742 parts of protoxide, containing 0·392 of oxygen, produced 3·124 of sulphide. Hence the 0·392 of oxygen was replaced by 0·774 of sulphur. The formula DiS requires 0·784.

Chloride.—The solution of oxide of didymium in hydrochloric acid is of a pure rose colour. When sufficiently concentrated by heat, it deposits on cooling, rose-coloured crystals of considerable size, consisting of the hydrated chloride. These crystals are deliquescent, which renders it difficult to determine their form. They are rhomboidal prisms of 78° , with an oblique base inclined 92° to the faces of the prism.

This chloride is very soluble in water and alcohol. Its solution cannot be evaporated to dryness without giving off hydrochloric acid; and on digesting the residue in water, part of it dissolves, but there remains a white insoluble residue, which is an oxychloride.

The composition of the chloride is as follows:

	Calculated.	Found.
Di . . . 48·0	40·18	40·25
Cl . . . 35·4	29·68	29·70
4 HO . . . 36·0	30·14	31·71
Di Cl, 4 HO . . . 119·4	100·00	

The insoluble oxychloride formed by evaporating the chloride to dryness, does not yield constant results on analysis. After drying *in vacuo*, it does not give off water at 100° , but loses from 10 to 11 per cent of its weight by calcination. Prolonged calcination in contact with the air does not appear to expel the chlorine, the compound not turning brown. It was analyzed by dissolving it in cold dilute nitric acid, and determining successively the chlorine and the oxide of didymium, the water being estimated by loss.

	Calculated.	Found.		
DiCl 83·46	37·52	35·60	31·48	36·62
2 DiO 112·00	50·35	53·36	55·64	52·09
3 HO 27·00	12·13	11·04	12·88	11·29
$\text{DiCl}, 2 \text{ DiO} + 3 \text{ HO}$	222·46	100·00		

These results show that the products of different preparations have not exactly the same composition, possibly because they contain portions of oxide in the state of simple mixture. After the oxy-

chloride has been exposed for some time to the air, it dissolves in acids with effervescence, which shows that it has absorbed carbonic acid.

Nitrate.—This salt is extremely soluble in water. Its solution is of a pure rose colour when dilute, but appears violet by reflected light when concentrated. A syrupy solution solidifies on cooling in a crystalline mass, but too deliquescent and too much saturated with mother-liquor to admit of a determination of the crystalline form.

It gives off its water with difficulty, not becoming anhydrous till it undergoes the igneous fusion at a temperature above 300°C . If it be very carefully raised to this temperature, it does not decompose, and is still capable of redissolving completely in water. It then exhibits the composition of an anhydrous neutral nitrate.

	Calculated.	Found.
DiO . . . 56·	50·91	50·48
NO ₅ . . . 54·	49·09	—
DiO, NO ₅ . 110·	100·00	

The anhydrous nitrate dissolves in alcohol of 96 per cent as readily as in water; the solution does not become turbid even on the addition of a large quantity of ether. The salt does not however dissolve in ether alone.

If it be raised to a higher temperature after fusion, it decomposes, giving off copious fumes of hyponitric acid. Soon afterwards it becomes pasty, swells up, and leaves a white, porous, light mass, which subsequently changes to the brown peroxide.

If the residue be treated with water when the decomposition has but just begun, the water dissolves out a portion of neutral nitrate, and leaves a white residue tinged with rose colour. This residue contains nitric acid without nitrous, as may be readily ascertained by treating it with sulphuric acid. The composition of this sub-salt is as follows:

	Calculated.	Found.	
4 DiO . . . 224	69·35	68·75	71·20
NO ₅ . . . 54	16·72	17·69	15·19
5 HO . . . 45	13·93	—	—
4 DiO, NO ₅ + 5 Aq. 323	100·00		

This product is very probably a mixture of a subnitrate with the protoxide of didymium, hydrated or anhydrous.

Phosphate.—A concentrated solution of phosphoric acid does not produce an immediate precipitate in a strong solution of nitrate of didymium, but at the end of an hour or two, a white, pulverulent precipitate is formed. The addition of a large quantity of water

causes the precipitate to form immediately. The greater part of the oxide of didymium is ultimately carried down in this precipitate. It is insoluble in water, very sparingly soluble in dilute acids, but dissolves readily in the strong acids when concentrated.

After desiccation *in vacuo*, it gives off by calcination 7.02 per cent, or 2 atoms of water. It is tribasic.

		Calculated.	Found.
PO ₅	. . . 71	29.71	—
3 DiO	. . . 168	70.29	70.19
3 DiO, PO ₅ .	. . 239	100.00	

Arseniate.—Arsenic acid does not precipitate the solutions of didymic salts at ordinary temperatures, even after a considerable time. But on boiling the liquid, a copious precipitate is formed, and very little oxide of didymium remains in solution. Neutral arseniate of potash instantly precipitates didymic salts at ordinary temperatures.

Arseniate of didymium prepared by either of these processes has the same composition. But when precipitated at a boiling heat, it is pulverulent, and remains so after desiccation; when precipitated in the cold, it is slightly gelatinous, and maintains after drying, a certain degree of transparence and a rose colour. It is but slightly soluble in dilute acids.

After drying *in vacuo*, it does not give off any water at 100°, but only by calcination; the proportion thus evolved cannot be precisely determined. For, after the water has been expelled, the salt gradually decomposes by roasting, and diminishes continually in weight. To obtain an exact determination of the water, it is necessary to calcine the salt with a known weight of oxide of lead. The rest of the analysis is made in the usual way, and leads to the following results:

	Calculated.	Found.
2 AsO ₅	. . 230 43.56	
5 DiO	. . 280 53.03	52.94 53.34 54.04 53.98 53.50
2 HO	. . 18 3.41	3.86 3.88
5 DiO, 2 AsO ₅ + 2 Aq.	528 100.00	

The composition of this salt being somewhat unusual, the analyses were repeated on samples prepared in various ways, sometimes with neutral, sometimes with strongly acid solutions, but always with the same result.

Carbonate.—The alkaline carbonates and bicarbonates produce in salts of didymium, very bulky, white precipitates, tinged with rose colour, completely insoluble in excess of the re-agents, and never appearing to assume the nacreous and lamellated aspect of

the carbonates of cerium and lanthanum, even after long immersion in the liquid in which they are formed.

The carbonate prepared in the cold with bicarbonate of ammonia and nitrate of didymium, and dried *in vacuo*, gave the following results on analysis:

		Calculated.	Found.
DiO	56	58.33	58.39
CO ₂	22	22.92	22.95
2 HO	18	18.75	
DiO, CO ₂ + 2 Aq. . .	96	100.00	

At 100°, this salt loses 14.36 per cent of its weight, corresponding to 1½ atom of water. But the analysis of the salt thus dried, proves that it has also lost a small quantity of carbonic acid:

		Calculated.	Found.
DiO	56.0	67.88	68.46
CO ₂	22.0	26.66	25.63
½ HO	4.5	5.46	
	82.5	100.00	

From this it would appear, that the neutral anhydrous carbonate cannot be obtained by drying the hydrated salt.

Sulphite.—Oxide of didymium, strongly calcined and suspended in water, is readily dissolved by a stream of sulphurous acid gas. The solution is of a pure rose colour. As soon as it is heated, it becomes very turbid, forming a very light and bulky precipitate, which redissolves as the liquid cools. But if the temperature be raised to the boiling-point, so as to expel the excess of sulphurous acid, the precipitate becomes pulverulent, of a rose-white colour, and no longer dissolves on cooling. The liquid retains mere traces of oxide of didymium, due to the formation of a small quantity of sulphuric acid, for the sulphite appears to be quite insoluble.

Suspended in water and exposed to a stream of chlorine, it dissolves readily, and is converted into sulphate; on evaporating the liquid to dryness, a residue of pure neutral sulphate is obtained. When ignited, it gives off sulphurous acid, and is converted into oxide mixed with a small quantity of subsulphate. After drying *in vacuo*, it retains 2 atoms of water, like the carbonate.

		Calculated.	Found.
DiO	56	52.83	53.36
SO ₂	32	30.19	30.42
2 HO	18	16.98	
DiO, SO ₂ + 2 Aq. . .	106	100.00	

Sulphate.—Formed by dissolving the oxide or carbonate in dilute sulphuric acid. The solution is rose-coloured, and deposits, by spontaneous evaporation, dark rose-coloured, shining crystals, having the form of an oblique rhomboidal prism. The crystals are often maced parallel to the anterior edge of the prism; they cleave readily and distinctly in a direction parallel to the base. They give off their water at 200° , leaving an anhydrous powder which may be heated to redness without undergoing any further alteration.

	Calculated.	Found.
DiO . . . 56	58.33	58.27
SO ₃ . . . 40	41.67	
DiO, SO ₃ . . 96	100.00	

The crystals differ altogether in form from those of the sulphate of lanthanum, and contain $\frac{1}{3}$ of an equivalent of water less. Crystallized sulphate of lanthanum contains 3 atoms of water; LaO, SO₃ + 3 Aq.; but the formula of the rhombic crystals of sulphate of didymium is 3 (DiO, SO₃) + 8 Aq.

	Calculated.	Found.
3 (DiO, SO ₃) . . 288	80	
8 HO 72	20	20.2
360	100	

The formula DiO, SO₃ + 3 Aq. requires 21.95 per cent of water.

A solution of the sulphate, when heated, especially to the boiling-point, deposits a crystalline precipitate containing only 2 atoms of water.

	Calculated.	Found.
DiO, SO ₃ . . . 96	84.21	—
2 HO 18	15.79	14.76
DiO, SO ₃ + 2 Aq. . . 114	100.00	

As the separation of lanthanum and didymium depends upon the difference of solubility of their sulphates, the author endeavoured to determine this point with some degree of exactness for the sulphate of didymium. Somewhat different results are obtained, accordingly as the anhydrous salt or either of the hydrates is dissolved, as may be seen by the following table, although the experiments were not made at exactly the same temperatures. The experiment was always commenced by dissolving the salt of saturation in cold water, then keeping the temperature stationary at higher and higher degrees, and each time for six or eight hours at the

least; a weighed portion of the solution was then evaporated to dryness, and the residue dried at a dull red heat. The numbers in the table indicate, in each instance, the proportion of anhydrous sulphate in 100 parts of water, free or combined, existing in the solution.

Temperature.	Anhydrous sulphate.	Sulphate with 2 atoms of water.	Sulphate crystallized in the cold.
12° C.	43.1	—	—
14	39.3*	—	—
18	25.8	16.4	—
19	—	—	11.7
25	20.6	—	—
38	13.0	—	—
40	—	—	8.8
50	11.0	—	6.5
100	—	—	1.7

The sulphate with 2 atoms of water does not attain its maximum of solubility till after a considerable time. Thus, at the temperature of 18°, the quantity of this salt dissolved in 100 parts of water was 13 after twenty-four hours, and 16.4 at the end of another day. This solution having been concentrated by evaporation *in vacuo*, till the greater part of the salt had separated out in crystals, the mother-liquor was found to contain 34 parts of the salt in 100. This salt appears thus to attain the solubility of the anhydrous sulphate. Moreover, the crystals which had formed were those of the hydrate with $\frac{8}{3}$ atoms of water.

Sulphate of didymium withstands a dull red heat, but is decomposed at a white heat. It is not completely decomposed by the heat of a spirit-lamp. A portion of anhydrous sulphate ignited for an hour in an intense charcoal fire lost 28.03 per cent of its weight, which is equivalent to 67.28 per cent, or nearly $\frac{2}{3}$ of the total quantity of sulphuric acid contained in it. In this manner the sub-sulphate, $3 \text{ DiO}, \text{SO}_3$, is obtained. It is a dull white powder, quite insoluble in water, either at ordinary temperatures or at the boiling-point. It dissolves but slowly in hydrochloric acid, even with the aid of ebullition, but dissolves readily in strong acids.

In another experiment, in which the ignition was not so strong, the loss of weight was only 17.5 per cent. The product treated with water separated into the soluble neutral sulphate and the insoluble sub-sulphate, exactly in the proportion indicated by this loss—a fact which demonstrates the actual existence of this tribasic sulphate.

Sulphate of Didymium and Ammonium.—On mixing the solutions of sulphate of didymium and sulphate of ammonia, there is formed,

* This number is probably too high, the solution not having been kept at that temperature for more than half an hour.

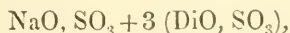
sooner or later according to the degree of concentration, a crystalline precipitate of a pale rose colour. This double sulphate dissolves in 18 times its weight of water, and is somewhat less soluble in a saturated solution of sulphate of ammonia.

Ignition at a dull red heat converts it into neutral sulphate of didymium, from the proportion of which, and that of the total amount of sulphuric acid, the composition of the salt may be determined :

		Calculated.	Found.
3 DiO	168	39.44	39.34
NH ₄ O	18	6.10	6.25
4 SO ₃	160	37.56	37.71
8 H ₂ O	72	16.90	16.70
NH ₄ O, SO ₃ + 3 (DiO, SO ₃) + 8 Aq. .	418	100.00	100.00

Of the 8 atoms of water, 6 atoms are driven off at 100°. The salt is not altered in composition by washing it till half is dissolved.

Sulphate of Didymium and Sodium.—A mixture of sulphate of didymium and sulphate of soda produces almost immediately, a pulverulent white precipitate, tinged with rose colour, which requires about 200 times its weight of water to dissolve it. In a solution of sulphate of soda it is still less soluble. Its very slight solubility renders it possible to determine its composition by synthesis. When the two salts were mixed in the proportion of 100 parts of sulphate of didymium to 37 of sulphate of soda, or 2 atoms of the former to 1 atom of the latter, the liquid, on being left to clarify and then decanted, still yielded a copious precipitate on the addition of a fresh portion of sulphate of didymium. But when the salts were mixed in the proportion of 25 parts (1 atom) of sulphate of soda to 100 parts (3 atoms) of sulphate of didymium, the clarified liquor gave no further precipitate with either salt. Hence the composition of the double salt is :



a result which is confirmed by analysis :

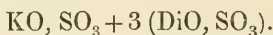
		Calculated.	Found.	
3 DiO	168	46.78	45.78	45.75
NaO	31	8.67	—	—
4 SO ₃	160	44.55	45.78	45.13
		359	100.00	

The salt with which the analyses were made, had been calcined. The crystallized salt contains water; but different samples gave

different quantities, doubtless because they had not been prepared under the same conditions of temperature.

Sulphate of Didymium and Potassium.—On mixing the solutions of sulphate of didymium and sulphate of potash, there is immediately produced, if the solutions are somewhat concentrated, and especially if the latter salt is in excess, a white pulverulent precipitate. It afterwards goes on forming slowly, assuming a more granular and crystalline texture and a deeper rose colour. This double salt is much more soluble than the corresponding soda-compound, dissolving in 63 times its weight of water.

The two sulphates appear to unite in more than one proportion; but the most stable compound appears to be that which corresponds to the sodium-salt, viz. :



It appears also to contain 2 atoms of water.

Oxalate of Didymium.—This salt, when precipitated from neutral liquids, is pulverulent and of a white colour, slightly tinged with rose; when redissolved by heat in an excess of nitric or hydrochloric acid, it separates, on cooling, in a granular and crystalline form, sometimes even in small rose-coloured crystals, having the form of rectangular prisms, terminated by a pyramid with four faces placed upon the angles of the prism. This salt is perfectly insoluble in water, nearly insoluble in oxalic acid and in dilute mineral acids.

After drying in the air, it leaves, by roasting and calcination, between 44 and 45 per cent of oxide of didymium, and gives off about 20 per cent of water at 100° , but the diminution of weight goes on for several days. The oxalate dried at 100° leaves 55.53 per cent of oxide of didymium. Hence it appears that the salt contains 4 atoms of water, 3 of which go off at 100° .

DiO . .	56	43.75	DiO . .	56	55.45
C ₂ O ₃ . .	36	28.12	C ₂ O ₃ . .	36	35.64
4 HO . .	36	28.13	HO . .	9	8.91

DiO, C ₂ O ₃ + 4Aq .	128	100.00	DiO, CO ₃ + Aq	101	100.00
--	-----	--------	---------------------------	-----	--------

The author concludes his paper with the following remarks :

“ During the whole of this research, I was pre-occupied with the idea that the oxide whose combinations I was examining, might be not a simple oxide, but a mixture of two oxides, one of which might possibly be that of lanthanum. I therefore attended, as minutely as possible to the circumstances which might confirm that supposition. I have, however, met with only two facts, which may to a certain extent confirm this suspicion, viz.: 1. The scarcely perceptible increase of weight produced by the peroxidation of

oxide of didymium, an anomaly which is most easily explained by supposing that this peroxidation affects but a small portion of the mass; and, 2. The anomalous proportion of water in crystallized sulphate of didymium, which might lead to the supposition that this salt is a mixture of two salts with different degrees of hydration; it is, however, difficult to admit such a supposition with regard to very distinct and well-formed crystals, selected out of a number."

"On the other hand, I tried a great number of experiments with the view of demonstrating the existence of two different oxides, if they had been really present, but without any positive result. Thus, I compared attentively the series of precipitates produced by adding ammonia in successive portions to a didymic salt—the series of insoluble residues obtained by decomposing the nitrate or chloride by heat and digesting in water, a considerable number of times in succession—also the series of solutions obtained by successively treating the oxide, peroxide, sulphide, or oxysulphide with portions of dilute acid, not sufficient to dissolve it completely; but I have never observed any difference between the products obtained at the beginning and end of either of these series of operations. Neither was any particular result obtained by the action of chlorine on oxide of didymium suspended in water. The hydrate dissolves readily, preserving its aspect unaltered to the last; the peroxide likewise dissolves, though more slowly; and the part which dissolves last, does not differ in any respect from that which is first attacked."

"Thus, in spite of the considerations above adduced, I think it must be admitted that, although my oxide of didymium may have contained some traces of oxide of lanthanum, not completely eliminated by the crystallization of the sulphate, it was nevertheless essentially composed of one oxide, whose properties were not sensibly modified by the slight impurity just mentioned."

Researches on the Cinchona Alkaloids.

By L. Pasteur.*

It is now about half a century, since *Cinchonine*, whose existence had been previously pointed out by Dr. Duncan, of Edinburgh, was first isolated and obtained in a state of purity, by Gomez, a physician of Lisbon. He attributed the efficacy of cinchona-barks to the presence of this body; but he failed to recognize its alkaline character, which, indeed, was not fully appreciated till towards the year 1820, by Pelletier and Caventou, at which time the same chemists likewise made the important discovery of *Quinine*. About twelve years

* Compt. Rend. XXXVII, 110.

later, two other French chemists, MM. Henry and Delohdre, discovered, in yellow cinchona-bark, a third alkaloïd to which they gave the name of *Quinidine*. In 1829, Sertürner, already celebrated by his discovery of morphine, observed in the mother-liquors of sulphate of quinine, an uncrystallizable base which he called *Quinoïdine*, and to which he attributed wonderful febrifuge properties.

The general characters of quinine and cinchonine are sufficiently well known; but with regard to quinidine and quinoïdine, very contradictory opinions still prevail. I think that I have removed all these difficulties. The results of my investigations likewise exhibit entirely new molecular relations between the several cinchona-alkaloïds. The following are the new facts which I have discovered.

1. *Cinchonicine*.—When cinchonine, in any of its salts, is subjected to the action of heat, it becomes transformed into a new base isomeric with it, but possessing totally different characters. This new base I call *Cinchonicine*. Any salt of cinchonine may be used for the preparation of cinchonicine; but to render the transformation easy and complete, and prevent it from going too far, the salt of cinchonine must be placed under certain conditions. In general, when a cinchonine-salt is heated, it immediately melts and decomposes; and if, by any particular artifice, we cause it to melt at a temperature considerably below that at which it decomposes, cinchonicine is produced; but if the heat be too strong, the new alkali is destroyed. Ordinary sulphate of cinchonine, for example, when directly heated, melts, and then immediately suffers decomposition, and is converted into a resinous substance of a fine red colour, which is a product of the transformation of the cinchonine. But if the sulphate, before it is heated, be mixed with a small quantity of water and sulphuric acid, it remains melted at a low temperature, even after all the water has been expelled, and if it be kept in this state for three or four hours, between 120° and 130° , it changes completely into sulphate of cinchonicine. The quantity of colouring matter formed is extremely small, indeed almost imponderable.

I prove, by facts which will be admitted by all chemists, that though heat plays an important part in this transformation of cinchonine, the vitreous, resinoid state of the product has nevertheless a real influence upon it; and that the isomerism of this base with cinchonine is due to transformations of the same kind that we meet with so frequently in Mineral Chemistry, as in soft sulphur, red phosphorus, and vitreous arsenious acid.

2. *Quinicine*.—All that has been said about cinchonine is applicable word for word, to the salts of quinine. When any salt of this base is heated, a new alkaloïd is formed isomeric with it. The conditions necessary and sufficient for ensuring this transformation are the same as those above indicated in the case of cinchonine. To the new base

I give the name of *Quinicine*. The best mode of obtaining it is to add a small quantity of water and sulphuric acid to commercial sulphate of quinine, and apply a moderate heat. The mass remains liquid even after the water has been completely expelled, and by continuing to heat it for four hours in an oil-bath to a temperature between 120° and 130° , the entire mass may be transformed into sulphate of quinicine, an extremely small quantity of colouring matter being formed at the same time.

In their general properties, cinchonine and quinicine exhibit well-marked resemblances to the isomeric bases from which they are derived. They, moreover, resemble each other in the closest manner. Both are nearly insoluble in water, but very soluble in alcohol, whether absolute or of ordinary strength. Both of them unite readily with carbonic acid, and expel ammonia from its salts at ordinary temperatures. Both are precipitated from their solutions in the form of resinous liquids, just like quinine under certain circumstances. Finally, both of them turn the plane of polarization to the right. They are equally bitter, and possess equal febrifugal powers.

3. *Quinidine*.—Allusion has already been made to the contradictions which are met with in the results of different chemists who have examined quinidine. All these contradictions may be attributed to a fact which has escaped the notice of former observers—viz.: that the name of quinidine has hitherto been applied indiscriminately to two alkaloids which are totally distinct in their physical and chemical properties, and are almost always mixed together in the quinidine of commerce, unless care has been taken to purify it by several successive crystallizations. Thus, the quinidine discovered in 1833 by Henry and Delohdre is totally different from the substance at present known by that name in France and Germany; and the German product often contains a considerable quantity of that which was discovered by Henry and Delohdre. The leading characters by which these two alkaloids may be distinguished from one another are the following: One of them, for which I shall retain the name of quinidine, is hydrated, efflorescent, *isomeric with quinine*, turns the plane of polarization to the right, and like quinine, acquires a green colour by the successive addition of chlorine and of ammonia. The other base, to which I give the name of *cinchonidine*, is anhydrous, *isomeric with cinchonine*, turns the plane of polarization to the left, and does not exhibit any green colouring under the circumstances just mentioned. It is this alkaloid which is most abundant in the samples at present met with in commerce. By exposing recently crystallized cinchonidine to warm air, it is very easy to see whether it contains any quinidine. All the quinidine-crystals effloresce rapidly but without change of form, and separate with a dull white colour from the crystals of cinchonine, which retain their transparency. The green colouring by chlorine and ammonia likewise affords a useful test.

It appears, then, that the principal bases contained in cinchona-barks are four in number—namely, quinine, quinidine, cinchonine, and cinchonidine.

4. *Action of Heat on Quinidine and Cinchonidine.*—These two bases, when subjected to the action of a moderate heat, undergo exactly the same transformations as quinine and cinchonine—that is to say, *quinidine*, like quinine, is converted into *quinicine*, and *cinchonidine*, like cinchonine, into *cinchonicine*, the conditions necessary for the transformation being exactly the same as those already mentioned.

The molecular relations indicated by these results assume a new character when we compare the rotatory powers of the six alkalies. Consider, in the first place, the three isomeric bodies—quinine, quinidine, and quinicine. Quinine turns the plane of polarization to the left, quinidine to the right, and both to a considerable extent. Quinicine also turns it to the right, but very feebly as compared with the other two. Similarly with cinchonine, cinchonidine, and cinchonicine. Cinchonine and cinchonidine turn the plane of polarization, the one to the right, the other to the left, and both to a considerable amount; cinchonicine turns it very slightly to the right. The most rational, or rather the necessary, interpretation of these results appears to be as follows:—The molecule of quinine is double, consisting of two active bodies, one of which turns the plane of polarization considerably to the left, the other very slightly to the right. The latter is stable under the influence of heat, and does not undergo any isomeric transformation; but remaining without alteration in quinicine, gives to that body its feeble power of rotation to the right. The other group, which, on the contrary, is very active, becomes inactive when the quinine is heated, and therefore transformed into quinicine. Quinicine, therefore, is quinine, in which one of the constituent groups has become inactive. Quinicine may also be quinidine in which one of the constituent groups has become inactive; but in quinidine, this very active group turns the plane to the right, instead of to the left, as in quinine, and is, in the same manner, united with the same feeble and instable group possessing right rotatory power, which remains unaltered in quinicine, and gives to it its feeble rotatory power in that direction. All these observations might be repeated, word for word, with regard to cinchonine, cinchonidine, and cinchonicine, which, in fact, are constituted exactly like their three congeners, for they exhibit precisely the same relations.

5. *Quinoidine.*—This body is always a product of transformation of the cinchona-alkalies. It originates in two different ways. It is produced in the preparation of sulphate of quinine, and especially in the American forests, when the woodman, after having stripped the bark from the tree, exposes it to the sun to dry it. The salts of

quinine, cinchonine, &c., contained in these barks are then transformed into resinous and colouring matters, which constitute the principal part of the quinoïdine of commerce. In fact, when any salt of quinine or cinchonine, either in dilute or concentrated solution, is exposed to the sun, even for a few hours only, it undergoes such a degree of alteration, that the liquid assumes a very deep red-brown colour. Further, this alteration is the same as that which takes place at a high temperature. I am, therefore, of opinion that in the preparation of quinine, cinchonine, &c., serious loss might be avoided, and the extraction of the alkalies greatly facilitated, if the cinchona barks were protected from light as soon as they are removed from the trees, and kept in the dark while they are drying. The manufacturer of quinine should carefully avoid the action of a strong light.

**Transformation of the two kinds of Tartaric Acid into Racemic Acid.
Discovery of inactive Tartaric Acid. New Method of separating
Racemic Acid into the two Tartaric Acids, Right and Left.**

By L. Pasteur.*

If, in examining the isomeric transformations of the alkaloïds mentioned in the preceding Memoir, we make use of the tartrates of those bases, and continue the action of the heat beyond the point at which cinchonine and quinine are formed, the modifying influence then extends to the tartaric acid itself. Thus, tartrate of cinchonine exposed to a gradually increasing heat, is first converted into tartrate of cinchonine. But if the heat be continued, the cinchonine becomes altered; it loses water, becomes coloured, and changes into quinoidine. At the same time, the tartaric acid likewise undergoes important modifications; and after five or six hours' exposure to a temperature of 170° , part of it is found to be converted into racemic acid. The tube must then be broken, the black resinous mass contained in it repeatedly treated with boiling water, the liquid filtered when cold, and mixed with excess of chloride of calcium. The whole of the racemic acid is then completely precipitated in the form of racemate of lime, whence it is easy to obtain the racemic acid itself.

The principal use of the cinchonine in this operation, is to impart a certain degree of stability to the tartaric acid, and enable it to bear, without destruction, a temperature which would alter it rapidly if it were in the free state. The transformation of the tartaric acid does

* Compt. Rend. XXXVII. 162.

not in any way depend upon the action exerted by cinchonine and cinchonicine upon polarized light. Tartaric ether—a compound in which tartaric acid is united to a substance which has no action on polarized light, but which can support a high temperature without destruction—yields, when subjected to the action of heat, a considerable quantity of racemic acid.

Racemic acid, thus artificially formed, is perfectly identical in all its physical and chemical properties with natural racemic acid. It possesses, in particular, this important character, of being resolvable into dextro-tartaric and lævo-tartaric acid, exhibiting equal and opposite rotatory powers in their combinations with bases.

This resolution of artificial racemic acid into dextro- and lævo-tartaric acids, leads to this consequence: that ordinary dextro-tartaric acid may be artificially transformed into its opposite—viz., lævo-tartaric acid; a consequence which is highly remarkable, especially when viewed in connection with the extraordinary fact, which will doubtless be explained at some future time, that we have never, by starting from an inactive body of any kind whatever, succeeded in producing a substance which acts upon polarized light; whereas nearly all the substances elaborated by nature in the vegetable organism are unsymmetrical, like tartaric acid.

This transformation of dextro-tartaric acid into racemic acid is rendered still more remarkable by the fact that lævo-tartaric acid may be converted into racemic acid under precisely similar circumstances. What a strange aptitude is revealed by these natural organic compounds! A group of unsymmetrical molecules, right and left, are, by the sole influence of a high temperature, half transformed into molecules of an opposite character, which, as soon as they are formed, unite with the former.

For a long time I regarded the production of racemic acid from tartaric acid as impossible. To this conclusion I was led by the following considerations: Racemic acid is a compound of dextro- and lævo-tartaric acids. The problem of transforming dextro-tartaric into racemic acid is the same as that of converting dextro-tartaric acid into lævo-tartaric. Now, all that can be done with the one acid may be done, under the same circumstances, with its opposite. If, therefore, any particular operation performed on the dextro-tartaric acid, converts it into lævo-tartaric, the same process applied to the latter should convert it into the former. The transformation appears, therefore, to be impossible. The utmost that we can hope to effect is the production of an inactive acid.

Happily, however, experiment has shown that these theoretical deductions were erroneous. Nevertheless, they have served me as a guide; and the less I was disposed to look for the transformation of tartaric acid into racemic, the more did I multiply my endeavours to discover inactive tartaric acid. Not only did the existence of this

latter appear possible from theoretical considerations, I was, moreover, aware of the intimate relation between tartaric and malic acid; and I had previously obtained inactive malic acid. Now, it was in looking for inactive tartaric acid, that I arrived at the formation of racemic acid. But, what is very remarkable—the very same operation yielded also considerable quantities of inactive tartaric acid. In other words, I obtained, together with racemic acid, a kind of tartaric acid which has no action whatever on polarized light, and is not resolvable, under the same circumstances as racemic acid, into dextro- and lævo-tartaric acid. This inactive tartaric acid is extremely curious; it crystallizes perfectly, and yields salts, which, for beauty of form, are not inferior either to the tartrates or to the racemates. I have already observed that, after treating with water the tartrate of cinchonine, which had been heated for several hours to 170° , and adding chloride of calcium, the racemic acid, formed at the expense of the tartaric, is precipitated in the form of racemate of lime. If now, the liquid be immediately filtered to remove the racemate, and then left at rest for twenty-four hours, an additional crop of crystals is obtained, consisting of pure inactive tartrate of lime, from which it is easy to obtain the inactive acid itself.

Lastly, I have ascertained that the inactive tartaric acid is produced in this operation at the expense of racemic acid previously formed. For if racemate of cinchonine be kept for some hours at 170° , a considerable portion is transformed into this same inactive tartaric acid.

Chemistry is now, therefore, in possession of four kinds of tartaric acid, viz.: Dextro-tartaric acid, lævo-tartaric acid, the compound of these two, viz.: racemic acid, and the inactive acid, which is neither right nor left, nor formed by the combination of the two. It is common tartaric acid *untwisted* (*detordu*) if I may use this expression, which roughly expresses my idea, and perhaps goes a little further—for we cannot be too cautious in the study of these difficult questions. Doubtless, this series of the four isomeric tartaric acids is a type, to which a large number of analogues will soon be discovered.

A serious difficulty may, however, be apprehended in the application of these new results. Thus, to pass from the right to the left term of the series, it is necessary to pass through racemic acid. Now what process have I given for the decomposition of racemic acid? It consists in the formation of the double racemate of soda and ammonia. The crystals obtained are of two kinds, which must be separated according to their hemihedric forms. In this process, however, there is no generality; the decomposition presents itself as an accident. It is certainly a very curious phenomenon, but we cannot assign any proximate cause for it; moreover, the sodio-ammoniac salt is the only one which exhibits this power of spontaneous decom-

position. Hence, it is very probable that in operating on bodies of any other series, we might obtain a substance analogous to racemic acid, but not possessing this power of decomposition, and consequently the inverse of the original compound might remain unknown. Such, indeed, was the state of the question not long ago; but I have recently discovered a process, not mechanical like that of the separation of the two kinds of tartaric acid in the crystals of racemate of soda and ammonia, but chemical, and depending on general principles.

I have, in fact, shown in a Memoir presented to the Academy a year ago, that the absolute identity of physical and chemical properties exhibited by right and left *symmetrical* bodies, no longer exists when then they are placed in contact with active bodies. Thus the dextro- and lævo-tartrates of the same active organic alkali differ altogether from one another in their crystalline forms, solubility, &c. It appeared, therefore, probable, that this dissimilarity might be made available for separating the two tartaric acids by whose union racemic acid is formed; and this result I have actually obtained, after many fruitless trials, by means of the two bases, quinine and cinchonine. Thus, in preparing the racemate of cinchonine, it always happens that when the liquid has attained a certain degree of concentration, the first crop of crystals formed consists almost wholly of lævo-tartrate of cinchonine, the dextro-tartrate remaining in the mother-liquid. A similar result is obtained with quinine, excepting that in this case the dextro-tartrate crystallizes out first. Whenever, therefore, an organic compound is suspected to possess a binary constitution analogous to that of racemic acid, its resolution should be attempted by combining it with an active body, which, by the necessary dissimilarity of properties in the compounds which it is capable of forming with the constituents of the complex group, may afford the means of separating them.

We are now, then, in possession of general methods for converting a dextro-compound into its opposite and symmetric lævo-compound and likewise into the corresponding inactive body.

On the compounds of Glycerine with Acids, and on the synthesis of the proximate principles of Animal Fats.

By M. Berthelot.*

Glycerine, discovered in 1779 by Scheele, was at first regarded as a gummy substance peculiar to certain oils, and, in a certain sense, of accidental occurrence. The notions at present entertained on

* Compt. Rend. XXXVII, 398.

its nature and chemical functions are wholly due to Chevreul. This chemist in his "*Recherches sur les Corps Gras*," shows that a whole class of these bodies may be separated by the action of alkalies into two distinct parts, with fixation of water, viz., a fatty acid which unites with the alkali (forming soap) and glycerine. Hence have arisen two hypotheses. Either stearin, olein, butyrin, &c., are composed of oxygen, carbon, and hydrogen in such proportions that one part of their elements represents a fatty acid, either fixed or volatile, while the other portion, *plus* water, represents glycerine; or, these bodies, stearin, olein, &c., constitute a species of salts formed of an anhydrous fatty acid, fixed or volatile, and anhydrous glycerine—that is to say, their constitution is analogous to that of the ethers. Another group of fatty bodies contains cetine, which is characterized by the property of transforming itself into margaric and oleic acid, and ethal. The constitution of cetine gives rise to the same hypotheses.

The latter point of view has since been more and more developed and verified. Dumas and Péligot have confirmed the analogies of ethal and alcohol, first pointed out by Chevreul. They have formed with this body compounds similar to the ethers, or to cetine. Pélouze, on the other hand, has formed, with glycerine, the sulphoglyceric and phosphoglyceric acids, compounds analogous to the vinic acids; and in conjunction with Gélis, he has formed *butyrin*, the first neutral fatty matter that has been artificially obtained.

Berthelot has succeeded in generalizing these results, and in uniting glycerine both with the fatty acids, properly so called, and with other acids, organic and inorganic. The bodies thus formed are neutral, and incapable of combining with alkalies. Some are crystalline, others liquid.

They belong to several series. One of these series is identical with that of the natural fats; another, which is the more numerous, consists of bodies analogous to the ethers. Moreover, all these bodies may be represented in constitution by an acid, *plus* glycerine, *minus* water.

They all, when treated with alkalies, slowly reproduce the original acid and glycerine. Treated with concentrated hydrochloric acid, they decompose in the same manner. Treated with alcohol and hydrochloric acid, they give rise to a double decomposition, yielding glycerine, and an ether of the acid previously united with the glycerine. These two reactions they exhibit in common with the natural fats. Finally, ammonia converts them into amides.

When subjected to the action of heat, they decompose and yield acrolein, with the exception of two which are volatile. Nevertheless, stearin, olein, margaric, and palmitin, in very small quantities, may be distilled in the barometric vacuum without yielding acrolein or

turning acid. The same fact was observed by Chevreul with regard to the natural fats.

These various bodies are obtained by the direct union of their two proximate principles, the acid and glycerine. This union is produced by prolonged contact of the two bodies in close vessels, at a temperature more or less elevated. Nearly all of them form likewise at ordinary temperatures, but in very small quantity. In certain cases, they are obtained by double decomposition between the ethers and glycerine.

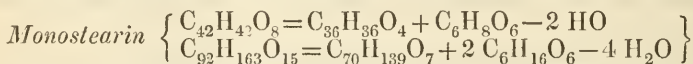
Lastly, they may be formed by the action of hydrochloric acid on the mixture of glycerine and the acid. It is worth while to remark the two opposite functions discharged by the hydrochloric acid; when dissolved in water, and added in large excess, it decomposes the neutral fats into glycerine and fatty acids; but when it acts in the form of gas on a mixture of syrupy glycerine and the acid, it causes the two bodies to combine.

These bodies may be divided into three groups—viz., 1. Compounds of glycerine with the fatty acids, properly so called (these combinations reproduce the fatty bodies which occur in the organic kingdom). 2. Compounds of glycerine with various organic acids, and not identical with any known compounds in the organic world. 3. Compounds of glycerine with mineral acids, likewise not identical with any known natural organic compound.

I.—COMPOUNDS OF GLYCERINE WITH THE FATTY ACIDS PROPERLY SO CALLED.

A.—Fixed Fatty Acids.

Stearin.—Stearic acid (melting at 70° C., prepared by Chevreul's method) forms with glycerine three compounds—viz., monostearin, distearin, and tetrastearin; the last of which is identical with natural stearin.



is obtained by heating a mixture of equal parts of glycerine and stearic acid to 200° for twenty-six hours. The glycerine and acid remain superposed without any appearance of dissolving one in the other. The neutral substance formed is likewise insoluble in the glycerine. After cooling, the solid stratum which floats on the excess of glycerine, is separated, fused, mixed with a small quantity of ether, then with slaked lime to separate the uncombined acid, and kept at 100° for a quarter of an hour. It is then exhausted with boiling ether (which does not separate stearic acid from lime under these circumstances). A white, neutral substance is thus obtained, very

slightly soluble in cold ether, and crystallizing in fine, double-refracting needles. These microscopic needles are usually grouped in rounded grains.

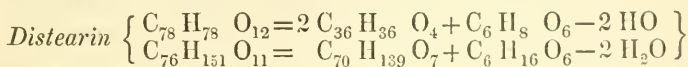
Monostearin melts at 61° and solidifies at 60° . It volatilizes without alteration in the barometric vacuum. Heated in the air, it begins to evaporate, and then decomposes with formation of acrolein. It burns with a white and very brilliant flame.

Treated with oxide of lead at 100° , it saponifies in a few hours, reproducing glycerine and stearic acid melting at 70° . The weight of glycerine thus reproduced amounts to nearly a fourth of that of the monostearin.

When kept for six hours at 100° in contact with strong hydrochloric acid, it is almost wholly resolved into glycerine and stearic acid. Acetic acid mixed with alcohol does not decompose it under the same circumstances. These various reactions are the same as those exhibited by natural stearin.

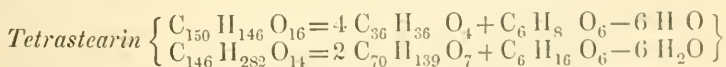
A similar compound is obtained by saturating with hydrochloric acid a mixture of syrupy glycerine and stearic acid at the temperature of 100° ; but the compound thus formed melts at 47° , and is mixed with chlorhydrin, from which it cannot be separated.

A mixture of glycerine and stearic acid, kept at the ordinary temperature of the air, yield traces of a neutral crystalline fat.



is obtained by heating a mixture of equal parts of glycerine and stearic acid to 100° for one hundred and fourteen hours. It is purified by lime and ether, like the preceding compound. It is white, neutral, granular, and when examined by the microscope appears to be composed of oblique, flattened, double refracting laminae. It melts at 58° , and solidifies at 55° . Yields acrolein when heated. When treated with oxide of lead at 100° , it reproduces glycerine and stearic acid fusible at 70° .

The same substance may also be obtained, either by heating the stearoglyceric mixture to 275° for seven hours, or by heating a mixture of 1 part monostearin and 3 parts stearic acid to 270° , or by heating natural stearin to 200° for twenty-two hours with excess of glycerine.



is obtained by heating monostearin to 270° for some hours, with fifteen or twenty times its weight of stearic acid. Water is eliminated, and condenses in the upper part of the tube. Combination does not take place by simple fusion; it requires time. This body is purified by lime and ether like the preceding.

Tetrastearin is neutral, and has the same composition as natural stearin.

2. *Margarins*.—Margaric acid (from human fat) forms with glycerine, two neutral compounds—viz., Monomargarin and Tetramargarin.

Monomargarin ($C_{40}H_{40}O_8 = C_{34}H_{34}O_4 + C_6H_8O_6 - 2HO$) is obtained either at 200° or at 100° . It is formed even at ordinary temperatures, but in very small quantity. Its formation is easier than that of any other solid fat. It melts at 56° , and solidifies at 49° . Treated with oxide of lead, it reproduces glycerine, and margaric acid melting at 60° . Its reactions are similar to those of stearin, excepting that, when heated to 100° for six hours with a mixture of alcohol and acetic acid, it is partially decomposed, yielding margaric acid and glycerine, a reaction not exhibited by stearin.

Tetramargarin appears to be formed by heating monomargarin to 100° with excess of margaric acid. It has not been obtained quite pure. When saponified, it yields margaric acid fusible at 60° , and glycerine.

It will be observed that the stearins, which are prepared with an acid melting at 70° , reproduce by saponification an acid which melts at 70° ; whereas the margarins, prepared with an acid melting at 60° , reproduce by saponification an acid melting at 60° . This fact confirms the existence of stearic and margaric acids as distinct and permanent bodies.

3. *Palmitins*.—Palmitic acid forms with glycerine three compounds analogous to those produced by stearic acid, and obtained under similar circumstances.

Monopalmitin ($C_{38}H_{38}O_8 = C_{32}H_{32}O_4 + C_6H_8O_6 - 2HO$), melting at 58° , solidifying at 45° ;

Dipalmitin ($C_{70}H_{70}O_4 = 2C_{32}H_{32}O_4 + C_6H_8O_6 - 2HO$), melting at 59° , solidifying at 51° ; and

Tetrapalmitin ($C_{134}H_{130}O_{16} = 4C_{32}H_{32}O_4 + C_6H_8O_6 - 6HO$), melting at 60° , solidifying at 46° . This last is identical with natural palmitin.

All these three compounds, when treated with oxide of lead, reproduce glycerine, and palmitic acid melting at 61° . Monopalmitin treated with alcohol and acetic acid for one hundred and two hours at 100° , is decomposed with separation of glycerine, a property likewise exhibited by natural palmitin.

4. *Olein*.—Oleic acid (purified by twice filtering the commercial acid at a temperature near 0° , then converting it into oleate of baryta, and crystallizing that salt from alcohol) forms at 200° a neutral *Monolein* ($C_{42}H_{40}O_8 = C_{36}H_{34}O_4 + C_6H_8O_6 - 2HO$). This compound is an oily liquid, which solidifies at near 15° . Its density is 0.947. Oxide of lead saponifies it very slowly, and with difficulty.

Alcohol and acetic acid do not decompose it at 100° , in which respect it resembles natural olein.

This body is also formed by double decomposition, by heating to 100° a mixture of oleic ether, glycerine, and hydrochloric acid.

Dirolein ($C_{78}H_{74}O_{12} = 2C_{36}H_{34}O_4 + C_6H_8O_6 - 2H_2O$) is obtained by heating natural olein with glycerine to 200° for twenty-two hours. Its density at 21° is 0.921. It begins to crystallize at 15° .

It is also obtained by heating monoolein with oleic acid.

B.—Volatile Fatty Acids.

These acids likewise unite with glycerine, under the same conditions as other fixed acids, producing by direct combination, various liquid compounds, which are neutral and odoriferous. These liquids may be decomposed by alkalis, by hydrochloric acid, and even by acetic acid or water, into acids and glycerine. A mixture of alcohol and hydrochloric acid converts them into ethers and glycerine. Alcohol alone, in large quantity, suffices to commence this double decomposition, either at 100° in eighty-eight hours, or at the ordinary temperature with access of air.

These compounds are prepared by heating the mixture of an acid with glycerine, adding excess of carbonate of potash after the liquid has cooled, then agitating with ether, evaporating in the water-bath, and drying *in vacuo* with the aid of heat.

The mere contact of glycerine with a volatile fatty acid continued for three months, at the ordinary temperature, is sufficient to form the compound in considerable quantity, at least in the case of butyric acid.

These bodies are likewise formed by the action of hydrochloric acid gas, or a mixture of glycerine with the acid, or even of glycerine with the ether of the fatty acid.

1. *Valerins*.—The following have been obtained:

Monovalerin ($C_{16}H_{16}C_8 = C_{10}H_{10}O_4 + C_6H_8O_6 - 2H_2O$) at 200° , is a neutral, oily, odoriferous liquid, which has a density = 1.100, and is slowly changed into valeramide by the action of ammonia.

Divalerin ($C_{26}H_{26}O_{12} = 2C_{10}H_{10}O_4 + C_6H_8O_6 - 2H_2O$) a neutral, oily liquid, having a disagreeable odour, a bitter, aromatic taste, a density of 1.059, is formed at 275° , by the action of the aqueous acid and glycerine.

2. *Butyrins*.—Butyric acid produces three compounds:

Monobutylin ($C_{14}H_{14}O_8 = C_8H_8O_4 + C_6H_8O_6 - 2H_2O$) is a neutral, oily, odoriferous liquid, having a bitter and aromatic taste, and a density of 1.088; it is formed in presence of excess of glycerine, either at ordinary temperatures, or at 200° . When saponified by baryta, it yields half its weight of butyric acid.

Dibutyryn ($C_{22}H_{22}O_{12}=2C_8H_8O_4+C_6H_8O_6-2HO$) is a neutral, only liquid, having a density of 1.081, volatilizing towards 300° , without apparent decomposition, mixing with alcohol and ether, slightly soluble in water; it is formed either at 275° or at 200° , with the aqueous acid. When saponified by baryta, it yields $\frac{2}{3}$ of its weight of butyric acid.

Butyridin ($C_{14}H_{13}O_7=C_8H_8O_4+C_6H_8O_6-3HO$) is a neutral, oily liquid, having an unpleasant odour, of medium fluidity, density = 1.084, soluble to a considerable extent in a solution of carbonate of soda; it is formed by heating to 200° a mixture of 1 part of glycerine and 4 parts of butyric acid. When treated with ammonia, it changes in the course of five days into butyramide.

3. *Acetins*.—Acetic acid, which in this point of view may be regarded as a fatty acid, forms two compounds, viz :

Acetin ($C_{10}H_{10}O_8=C_4H_4O_4+C_6H_8O_6-2HO$), a neutral liquid, of slightly ethereal odour, density = 1.20; formed at 100° , and *Acetid* ($C_{10}H_9O_7=C_4H_4O_4+C_6H_8O_6-3HO$), a neutral, odoriferous liquid, having a pungent taste, mixing with water, volatile at 280° , having a density = 1.184. It is formed under the most different circumstances, either at 275° or at 200° , in presence of excess of glycerine, or excess of acid, aqueous or not. When saponified by baryta, it yields glycerine, and half its weight of acetic acid.

II.—COMPOUNDS OF GLYCERINE WITH VARIOUS ORGANIC ACIDS.

Glycerine may be made to unite with benzoic, sebacic and camphoric acid, merely by the action of time and of heat.

Benzoycin ($C_{20}H_{12}O_8=C_{14}H_6O_4+C_6H_8O_6-2HO$) is a light-coloured, very viscid oil, nearly or quite inoxidable, of density 1.228; it is formed either at 200° or 270° , and may be purified in the same manner as butyryn. It begins to form at 100° , or even at the ordinary temperature, and is also produced by the action of hydrochloric acid on a mixture of glycerine and benzoic ether, or even by the direct action of glycerine in large quantity on benzoic ether at 100° . Alkalies convert it into benzoic acid and glycerin; alcohol and hydrochloric acid, into benzoic ether and glycerine; the same decomposition is likewise produced even by alcohol alone, when in large quantity, either at 100° , or at ordinary temperatures with access of air. Lastly, ammonia converts it into benzamide.

Sebin ($C_{32}H_{30}O_{10}=C_{20}H_{18}O_8+2C_6H_8O_6-4HO$) is obtained at 200° . It is a neutral, crystallizable body, resolved by oxide of lead into sebacic acid and glycerine.

Camphorin is neutral, viscid like thickened turpentine, soluble in ether, decomposable by oxide of lead into acid and glycerine.

III.—COMPOUNDS OF GLYCERINE WITH MINERAL ACIDS.

Chlorhydrin ($C_6 H_7 ClO_4 = C_6 H_8 O_6 + HCl - 2 H_2O$) is obtained by saturating glycerine at a gentle heat with hydrochloric acid gas, and keeping the solution at 100° for thirty-six hours. Without this precaution, only traces of the product are obtained. The solution is then saturated with carbonate of soda, agitated with ether, and the ether evaporated. The residue of this operation, when subjected to distillation, yields chlorhydrin at 227° (a fixed point). It must then be treated a second time with lime and ether. Chlorhydrin is a neutral oil, having a fresh and ethereal odour, a saccharine taste, with a pungent after-taste, and mixing with water and ether; its density is 1.31.

It does not precipitate nitrate of silver, at least not immediately. It burns with a white flame bordered with green, eliminating hydrochloric acid. Oxide of lead saponifies it slowly and with difficulty, yielding quantities of glycerine and hydrochloric acid, nearly proportional to the equivalents of those bodies.

The glyceric compounds prepared by the action of hydrochloric acid on glycerine and an acid, all contain chlorhydrin united, or we may say allied with them, and it cannot be separated from them completely.

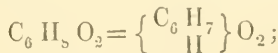
Chlorhydrin is also formed, though merely as a trace, by the action of strong hydrochloric acid on the neutral fats.

On Propionic Alcohol.

By G. CHANCELLOR.

This alcohol, to which the author gives the name of *Hydrate of Trityl*, has been obtained from the residue of the distillation of *esprits de marcs*, a product which had been previously shown by Balard to consist of amylic alcohol. The first portions of the distillation of these residues were rectified several times, and purified by a method which will be described elsewhere. The product was agitated with carbonate of potash, to remove the greater part of the water, then left for twenty-four hours in contact with fused hydrate of potash, and distilled over that substance.

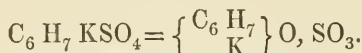
Hydrate of Trityl (which may also be called Propionic or Propylic Alcohol) contains :



It is a perfectly limpid liquid, lighter than water, and having a fruity, intoxicating odour. It is very soluble in water, though it does not dissolve in that liquid in all proportions. It boils at 96° .

Its vapour density = 2.02, corresponding to 2 vols. for the above formula. It unites readily with sulphuric acid.

Sulphotritylic Acid is obtained in the state of a potash-salt, by saturating with carbonate of potash, a mixture of sulphuric acid and hydrate of trityl diluted with water; evaporating to dryness over the water-bath; and exhausting the residue with boiling absolute alcohol, which dissolves the sulphotritylate of potash. This salt contains



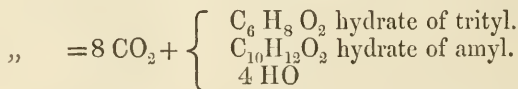
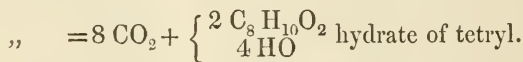
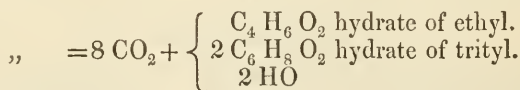
As the solution cools, the salt is deposited in delicate needles, very soluble in water and anhydrous.

Tritylo-sulphocarbonic Acid is likewise obtained in the form of a potash-salt, by dissolving caustic potash in hydrate of trityl, and adding sulphide of carbon to the solution. The salt is then deposited in slender needles.

Hydrate of trityl readily combines with other acids to form compound ethers.

This alcohol is probably not the only one which accompanies the hydrate of amyl in the *huiles de mare*. M. Faget is at present engaged in examining the less volatile portions, with the hope of discovering the higher homologues.

The formation of the different alcohols by the decomposition of sugar or glucose under the influence of ferments, may be represented by the following equations:



The last equation seems to show that the formation of hydrate of amyl is necessarily accompanied by that of hydrate of trityl.

THE
QUARTERLY JOURNAL
OF THE
CHEMICAL SOCIETY.

XXII.—*On two new methods for the determination of Nitrogen in organic and inorganic compounds.*

BY MAXWELL SIMPSON, M.D., DUBLIN, F.C.S.

Having been recently engaged in investigating the constitution of several interesting nitro-compounds, my progress was arrested by the difficulties I encountered in the determination of the amount of their nitrogen. In fact, all the methods of analysis at present known proved inapplicable. From the peculiarity of the constitution of these bodies, I could not with safety employ the soda-lime process. I had, therefore, recourse to Liebig's qualitative method, but totally failed, in consequence of oxide of copper being incapable of effecting complete combustion of these compounds, they being remarkably rich in carbon. I did not try Dumas' or Bunsen's method, as the same source of failure obviously exists in both.

With a view of removing this difficulty, and at the same time of supplying a want which has been long felt in organic chemistry, I commenced the present research, which has for its object the discovery of a new method for the determination of nitrogen, which shall be easy of execution, accurate, and at the same time general in its application.

The methods I am about to describe will, I have no doubt, be found applicable to the analysis of almost all nitrogenous compounds, whether organic or inorganic. The first, which is a comparative method, may be employed for the analysis of those bodies in which the amount of the nitrogen bears a considerable proportion to that

of the carbon. Bodies containing 1 equivalent of nitrogen to 10 or even 15 equivalents of carbon, may be safely analysed according to this process. The second, which is an absolute method, is applicable to the analysis of almost all substances, whether rich or poor in nitrogen.

COMPARATIVE METHOD.

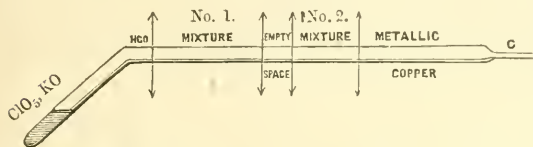
The principle of this method is the same as that of Liebig's. The organic substance is burnt, and the evolved gases, namely, carbonic acid and nitrogen, are collected in a graduated tube over mercury, and their relative proportion ascertained by absorbing the former by means of caustic potash. The combustion of the organic compound is, however, effected by means of oxide of mercury instead of oxide of copper. The employment of the former as the agent of combustion involves the necessity of using a large quantity of metallic copper in the fore-part of the combustion-tube, to absorb the free oxygen, which would otherwise enter the graduated jar and vitiate the analysis. No explosion is to be apprehended, as the oxygen in the combustion-tube is largely diluted with mercurial vapour. It is of course necessary in this, as in Liebig's process, that the amount of carbon in the substance intended for analysis should have been previously determined.

It is indispensable to the success of this method, that all the substances employed in it should not only be free from nitrogen, but from all bodies capable of absorbing carbonic acid, such as potash, baryta, &c. Now as the red precipitate of commerce is frequently contaminated with nitric acid, it is quite inapplicable; it therefore becomes necessary to prepare it specially for the process. The following is the best manner of preparing it.

A solution of corrosive sublimate is treated with an excess of caustic potash (an excess is necessary, in order to prevent the precipitation of an oxychloride), and the precipitate, which is thrown down, is washed by decantation till the supernatant liquor ceases to turn red litmus blue. It is next transferred to an evaporating basin, the liquor removed by a pipette, and a solution of phosphoric acid added, drop by drop, till the moist mass acquires a distinctly acid reaction, and retains it even after stirring. Finally the mercury is dried, heated pretty strongly, and preserved in a well-stoppered bottle for use. The addition of phosphoric acid effectually secures the absence of free potash. It is advisable to prepare it by burning a little phosphorus under a bell-jar. I shall now describe the process in detail.

A narrow combustion-tube, of hard and tolerably thick Bohemian glass, 32 inches in length, is selected and sealed at one end. A quantity of chlorate of potash, about 8 or 9 grms., which has been previously fused and powdered, is now introduced, and about 3 inches beyond it, the tube is bent into an obtuse angle, as represented in Fig. 1. A plug of freshly ignited asbestos is

FIG. 1.



driven up to this angle, which it should fit pretty tightly and yet permit the passage of gas. The interval between the chlorate

and the asbestos is for the purpose of giving room for the frothing up of the former on the application of heat. Two grammes of oxide of mercury are next added, and then a second asbestos plug. One decigramme of the substance intended for analysis is weighed out, and intimately mixed with $4\frac{1}{2}$ grms. of oxide of mercury and $1\frac{1}{2}$ grms. of oxide of copper.* The copper is employed simply to dilute the mixture and to make up for defective mixing, as the above quantity of oxide of mercury is quite sufficient for the complete combustion of 1 decigramme of any organic substance. This mixture is transferred to the tube, and so disposed as to form a stratum of 6 or 7 inches in length.

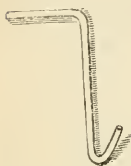
An asbestos plug is now introduced, and then a second, distant about 2 inches from the first, an empty space being left between the two as shown in Fig. 1. A second organic mixture is next formed, composed of 3 grms. of oxide of mercury, 1 grm. of oxide of copper, and 0.07 grm. of substance, which is also transferred to the tube and arranged so as to occupy about 4 inches of it. A quantity of finely-divided metallic copper, about 8 or 10 grms., is finally placed in the fore-part of the tube, a little asbestos separating it from the organic mixture, and spread out so as to form a thin layer, of about 6 or 7 inches in length.† The tube being thus filled, is drawn out in front about 2 or 3 inches, and a gas-delivery tube, having the form

* I would strongly recommend the employment of a mixture of equal parts of oxide of copper and oxide of mercury for the determination of carbon in graphite, carburets of iron, albumen, and other substances difficult of combustion. Liebig's apparatus for organic analysis may be employed without modification. The determination of the hydrogen must, however, be given up, as mercurial vapour would condense in the chloride of calcium, and increase its weight.

† The copper is best prepared by reducing oxide of copper by means of hydrogen gas. If the reduction be effected at a low temperature, the copper is obtained in a very minute state of division, and is admirably fitted for the absorption of oxygen.

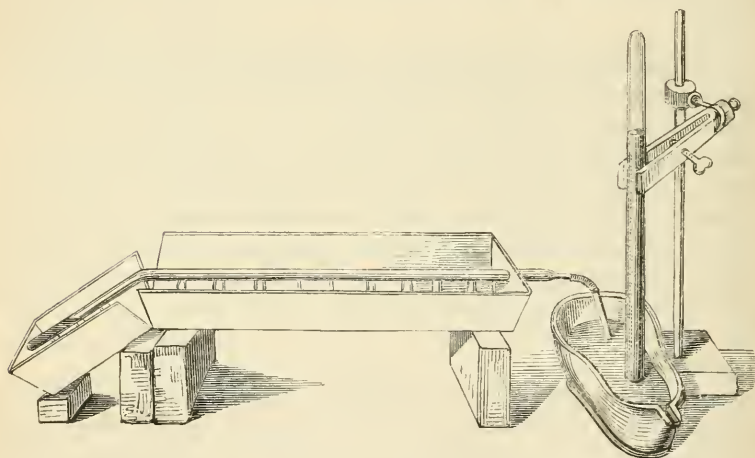
represented in Fig. 2, is attached to it by means of a caoutchouc joint.

FIG. 2.



Two combustion-furnaces are now arranged in such a manner as to form an obtuse angle with each other, as represented in Fig. 3. An old furnace may be made to answer remarkably well, if it be cut across, at a distance of about 12 inches from the extremity. The tube is arranged on the furnaces with 1 inch of the wide part projecting beyond the anterior one, as shown

FIG. 3.



in the drawing. This is necessary for the preservation of the caoutchouc connector, as the narrow part of the tube with which it is in contact becomes highly heated during the combustion, from the condensation in it of a large quantity of mercurial vapour.

The delivery-tube is now plunged beneath the surface of mercury in a mercurial trough, and heat is cautiously applied to the chlorate, so as to produce a rapid but not tumultuous evolution of gas (*See Fig. 3*). When the transmission of gas has proceeded for a short time, it is advisable to heat gently the unmixed oxide of mercury at the angle of the tube, so as to produce a slight disengagement of oxygen, and thereby more completely to remove the atmospheric air mechanically retained in its pores. When the chlorate is nearly exhausted, the tube is heated to redness from its sealed extremity to its angle, and maintained at a red heat during the entire process, in order to prevent products of decomposition distilling back into this part, on the application of heat to the organic mixture.

Having thus driven the atmospheric air completely out of the tube and replaced it by oxygen, the next step is to burn the organic mixture No. 2, and allow the gaseous products to escape through the mercury into the air without being collected. The object of this will be afterwards explained. The combustion is conducted in the following manner.

The empty space (Fig. 1), which must be shaded by an iron screen at each end, in order to prevent the heat from extending to the organic mixtures, is heated first, and afterwards the metallic copper. The latter is quickly raised to a full red heat, and as soon as the mercury is observed to rise in the delivery-tube, from the absorption of oxygen by the copper, a small quantity of the mixture No. 2 is heated, beginning with the anterior part, the rest being protected by a screen. The combustion of the entire mixture is proceeded with by gradually shifting back the screen and exposing a small quantity of it at a time to the action of the fire. The empty space as well as the metallic copper must be maintained at a full red heat during the entire combustion. The object of heating the former is to prevent products of decomposition, on the application of heat to the mixture No. 2, from distilling back to mixture No. 1, which products might differ from the original substance in the relative proportion of their carbon and nitrogen.

We have thus, by the burning of the anterior mixture, removed the oxygen from that part of the combustion-tube which is in front of the metallic copper, and from the delivery-tube (the oxygen behind the copper does not interfere with the process, as it cannot pass the red-hot metal), and replaced it by a gaseous mixture of the same composition as that which the combustion of the posterior mixture will afford. The tube being now in a proper condition, the fire may be extended to mixture No. 1 (Fig. 1), and the gaseous products may now be collected. This is done in the following manner.

A eudiometer is filled with mercury, and all air-bubbles having been carefully removed, it is inverted and plunged beneath the surface of the mercury in the trough, and as soon as the evolution of gas from mixture No. 2 has ceased, the delivery-tube is brought under it, and the combustion of mixture No. 1 is commenced, (Fig. 3). Before filling the eudiometer, it is necessary to moisten the inside with a drop of water, in order that the gas afterwards to be collected in it may be saturated with moisture, a condition requisite for its accurate measurement. An ordinary Bunsen's eudiometer will answer very well, provided it possess the necessary capacity. The

tube I usually employed was 550 millimetres in length, had an internal diameter of 21 millimetres and a capacity of about 200 cubic centimetres. This I found quite large enough to contain the products of combustion from 1 decigramme of substance. It is of course not necessary that it should be provided with platinum wires. For the method of constructing and graduating a eudiometer, I must refer to the "*Handwörterbuch der Chemie*," vol. II, p. 1053.

The eudiometer being placed on the delivery-tube, the combustion of mixture No. 1 is commenced, and so conducted as to produce a slow but uninterrupted evolution of gas. As soon as the combustion is terminated, heat is applied to the unmixed oxide of mercury at the angle of the tube, in order that the oxygen evolved may drive the last portions of gas into the eudiometer. When the operation is at an end, the eudiometer is disconnected and transferred to a mercurial trough with glass sides.

At the expiration of six or seven hours, the volume of gas is read off and properly corrected for temperature and aqueous vapour. An observation cannot with safety be made sooner, since both the gas and the column of mercury in the eudiometer (which must be afterwards compared with a cold barometric column) acquire a very high temperature during the combustion, in consequence of their proximity to the furnace. A potash ball, attached to a platinum wire, is now moistened with water and introduced into the eudiometer. It should be made in such a manner as to contain as much water of crystallization as possible in addition to its basic water.* As soon as the absorption of the carbonic acid is complete and the residual nitrogen quite dry, the ball is withdrawn and a second observation is made. This corrected for temperature and pressure, gives the nitrogen, and the difference between this and the first gives the carbonic acid.

The advantages which this method offers are :

1st. Complete combustion of the organic substance is secured, as it is burnt in an atmosphere of oxygen gas.

2nd. The formation of all oxides of nitrogen is entirely prevented, by the incandescent mercurial vapour with which the tube is filled during the combustion.

3rd. From the method of the analysis we are enabled to collect almost the whole of the gas evolved in the combustion of the posterior organic mixture, so that the carbon and nitrogen might be almost quantitatively estimated. It is true, that at the termination of the combustion, a small quantity of gas remained in the delivery-tube,

* *Handwörterbuch*, II, 1063.

which could not be driven into the eudiometer by the oxygen; but this is compensated by the delivery-tube having been full of gas from the anterior mixture, when the combustion of the posterior one was commenced, which was of course driven into the eudiometer.

Should the operator apprehend that oxygen has passed into the eudiometer, he can at once satisfy himself on this point by examining the tube after the combustion. In a well-conducted analysis, there will always be 2 or 3 inches of perfectly bright metallic copper in the fore-part of the tube.

I shall now give the results of the analyses that were made, in order to test the accuracy of this method. The substances employed were all obtained from Merck's establishment in Darmstadt, and were remarkably pure.

URIC ACID.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 1 ^{mm} pressure.
Vol. of mixed gases					
CO ₂ + N (moist)	471.05	17.3°	117.0 ^{mm}	743.3 ^{mm}	270.94
After absorption of					
CO ₂ (dry)	219.54	17.2°	363.4 „	742.4 „	78.27

Relation by volume.

Theory	2.5 C. : 1.000 N.
Experiment	2.5 „ : 1.015 „

CAFFEINE I.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 1 ^{mm} pressure.
Vol. of mixed gases					
CO ₂ + N (moist)	489.28	18.5°	103.7 ^{mm}	740.0 ^{mm}	284.32
After absorption of					
CO ₂ (dry)	183.62	18.5°	403.1 „	738.3 „	57.64

Relation by volume.

Theory	4 C. : 1.000 N.
Experiment	4 „ : 1.017 „

CAFFEINE II.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 1 ^{mm} pressure.
Vol. of mixed gases					
CO ₂ + N (moist)	406.98	19.1	149.3 ^{mm}	743.2 ^{mm}	219.65
After absorption of					
CO ₂ (dry)	141.95	18.7	411.4 „	745.8 „	44.42

Relation by volume.

Theory	4 C. : 1.000 N.
Experiment	4 „ : 1.014 „

ASPARAGIN.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 1 ^{mm} pressure.
Vol. of mixed gases					
CO ₂ + N (moist)	347·15	18·9	194·7 ^{mm}	743·2 ^{mm}	172·82
After absorption of					
CO ₂ (dry)	110·49	19·5	407·9 „	741·4 „	34·58
Relation by volume.					
		Theory	4 C. : 1·000 N.		
		Experiment	4 „ : 1·0007 „		

HIPPURIC ACID.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 1 ^{mm} pressure.
Vol. of mixed gases					
CO ₂ + N (moist)	423·24	19·4	124·4 ^{mm}	736·7 ^{mm}	235·35
After absorption of					
CO ₂ (dry)	54·7	19·4	485·4 „	736·3 „	12·81
Relation by volume.					
		Theory	18 C. : 1·000 N.		
		Experiment	18 „ : 1·036 „		

QUININE.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 1 ^{mm} pressure.
Vol. of mixed gases					
CO ₂ + N (moist)	441·18	17·5	112·9 ^{mm}	739·7 ^{mm}	253·78
After absorption of					
CO ₂ (dry)	55·9	18·4	493·4 „	741·9 „	13·01
Formula. Relation by volume.					
		C ₂₀ H ₂₂ N ₂ O ₄ }		Theory 19 C. : 1·000 N.	
		(Laurent's) }		Experiment 19 „ : 1·027 „	

The method I have just described is proposed as one remarkably easy of execution, and sufficiently accurate for the analysis of compounds rich in nitrogen. Indeed, greater accuracy cannot be attained by Dumas' absolute method, in which from 3 to 6 decigrammes of substance are employed, and all the trouble of drying and accurately weighing it must be gone through.* The error in all these analyses, it will be observed, is always in the same direction, and may with perfect safety be taken into account in all results obtained by this method.

The sources of inaccuracy are :

1st. Air adheres with great obstinacy to the oxide of mercury in

* Handbuch der Analytischen Chemie, von Rose, II, 814.

the combustion-tube, and cannot be entirely removed, even by a protracted transmission of gas. From the method of the analysis, however, it is the air adhering to the posterior mixture alone, amounting only to 6 grms., which enters the eudiometer and affects the accuracy of the analysis.

2nd. From the principle of the method, the accuracy of the results depends upon the correctness of the *carbon* determination.

3rd. It is impossible to introduce the potash-ball into the eudiometer without at the same time admitting a little air.

If greater accuracy be sought than can be attained by this method, or if a body poor in nitrogen is to be analyzed, the following or absolute method must be employed, in which almost all these sources of error are avoided.

ABSOLUTE METHOD.

The principle of this method is the same as that of Dumas. A known weight of the substance intended for analysis is burnt in a tube from which the atmospheric air has been previously expelled by means of carbonic acid, and the gaseous products are collected over mercury in a gas-vessel containing a solution of caustic potash. All the carbonic acid is absorbed, and nothing but nitrogen is left. The volume of the latter is afterwards ascertained, and its weight determined by calculation.

To furnish the carbonic acid required in this process, I have always employed carbonate of manganese in preference to bicarbonate of soda or carbonate of copper, which are usually employed in processes of this description, as it contains more available carbonic acid, and I believe less water than those substances. It may be economically prepared from the impure chloride of manganese, which accumulates to such an extent in most laboratories from the preparation of chlorine gas. This is evaporated to dryness, dissolved in water, filtered, and a solution of carbonate of soda added gradually, till all the iron is thrown down. The liquor is again filtered, and treated now with an excess of carbonate of soda, which precipitates all the manganese as carbonate. The precipitate is well washed by decantation, dried in a water-bath, and preserved in a well-stoppered bottle for use.

In this, as in the preceding method, oxide of mercury is employed as the agent of combustion, and must be prepared in the same manner. I will now give a detailed account of the process.

A combustion-tube of hard glass, $2\frac{1}{2}$ to 3 feet in length and

having tolerably thick walls, is selected, and sealed at one end. Twelve grammes of carbonate of manganese are now intimately mixed in a mortar with 2 grms. of oxide of mercury, and the mixture is

FIG. 4.



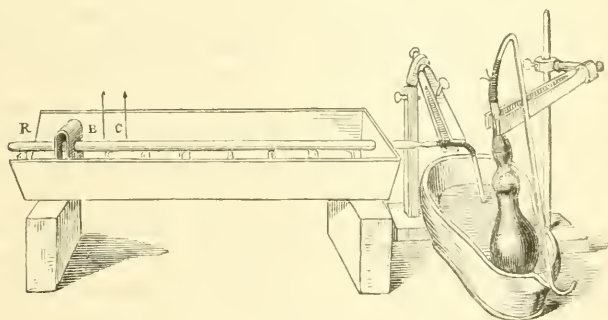
transferred to the tube (Fig. 4). The oxide is added in order to prevent the possible formation

of carbonic oxide, from the presence of organic matter in the manganese, or from other causes. At a distance of 1 inch from the carbonate, a plug of freshly ignited asbestos is placed, so that on bringing the tube into a horizontal position, a channel may be left for the passage of gas. A quantity of the substance intended for analysis, having been previously reduced to powder and dried in a water-bath till it had ceased to lose weight, is now introduced into a small glass tube, and accurately weighed. About 5 or 6 decigrammes of it are next carefully transferred to a well-glazed mortar, and the tube is weighed a second time, the difference between the two weighings giving the exact quantity of substance employed in the analysis. Some freshly ignited oxide of copper and oxide of mercury are now intimately mixed in a mortar, in the proportion of 2 parts of the former to $2\frac{1}{2}$ of the latter. This mixture is dried in an evaporating basin, and a quantity of it is weighed out, sufficient to furnish $4\frac{1}{2}$ grms. for the combustion of each decigramme of substance taken (6 decigrammes of substance requiring therefore 27 grms. of the mixed oxides). This will afford quite enough oxygen for the complete combustion of any organic compound. It is next added to the mortar containing the substance for analysis, and most intimately mixed with it, and the whole is transferred, without loss, to the combustion-tube, about 1 gm. of unmixed oxide of mercury having been previously introduced (Fig. 4). The mortar is then rinsed with a little pure oxide of copper and a little of the mixture, which are also transferred to the tube. A plug of asbestos is now introduced and placed at a distance of about 10 or 11 inches from the former plug, so that on bringing the tube into a horizontal position, the organic mixture may not form too thick a stratum. The asbestos should be made to sweep before it every particle of the organic mixture adhering to the walls of the tube. A quantity of pure oxide of copper, sufficient to occupy about 2 or 3 inches of the tube is next added, then another asbestos plug, and finally about 12 or 15 grms. of finely-divided metallic copper, prepared in the same manner as for the preceding process. The

copper should be made to occupy about 7 or 8 inches of the tube (Fig. 4). The tube is now drawn out and a delivery-tube attached to it by means of a caoutchouc connector, of the same size and shape as that used in the former method, with this exception, that the extremity which is to be plunged beneath the mercury, forms a right instead of an acute angle. A few taps on a table suffice to shake together the contents of the tube, so as to leave a free passage for the evolved gases from end to end.

The tube being thus prepared, is arranged in the combustion-furnace, with 1 inch of the wide part projecting beyond it, and the delivery-tube is plunged beneath the surface of the mercury in the mercurial trough, and kept in this position by means of a wooden holder (Fig. 5). A screen is now placed over the tube, at a

FIG. 5.



distance of $1\frac{1}{2}$ to 2 inches from the sealed extremity; hot coals are laid over the part so separated, *R*, for a few minutes until the carbonic acid evolved has expelled all the atmospheric air, and are then transferred to the other side of the screen and placed over the posterior half of the remaining carbonate *B*, which is heated in such a manner as to produce a pretty brisk evolution of gas. When the disengagement of gas begins to decline, the fire is extended to the anterior half of the manganese *C*, and the metallic copper and unmixed oxide in the fore-part of the tube are at the same time raised to a red heat, the organic mixture being of course protected from the heat by means of a screen. The carbonic acid in its passage over the red-hot copper and oxide, sweeps before it every trace of air mechanically adhering to them. As soon as the evolution of gas has ceased, the end of the delivery-tube, without of course allowing it to rise above the surface of the mercury, is introduced into the gas-apparatus

represented in Fig. 5, which has been previously filled carefully with mercury, with the exception of the top, which contains 16 or 17 cubic centimetres of a concentrated solution of potash, and the fire is extended to the organic mixture. During the entire combustion, that part of the tube where the exhausted manganese lies, must be maintained at a red heat.

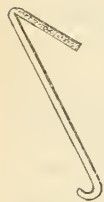
Before proceeding further, it will be necessary to give a minute description of this gas-apparatus and the method of constructing it, particularly as I believe it will be found capable of extensive application. A glass vessel is procured, of the shape represented in Fig. 6, and having a capacity of about 200 cubic centimetres; the

FIG. 6.



top should not be more than 7 or 8 millimetres in outer diameter. A tube of thick vulcanized caoutchouc, $1\frac{1}{2}$ inches in length, is slipped over the top, which it must accurately fit, to the extent of half an inch, and securely bound round it with silk cord, 1 inch of tubing being thus left above the apparatus. A glass rod, half an inch long, with the ends ground flat, and having the same diameter as the caoutchouc tube, is pressed down the latter till it touches the gas-vessel. A piece of thermometer tubing, also of the same diameter as the caoutchouc and having a fine hair-bore, is now bent into the form represented in Fig. 7, and also

FIG. 7.



inserted. The caoutchouc is next slightly stretched over it, and at the same time firmly secured with silk cord, so that there shall be no interval between the glass rod, bent tube, and gas-vessel. A silk cord is lastly tied round that part of the caoutchouc where the solid rod lies. Before using this apparatus, the joints must be tested by partially filling it with mercury, plunging the mouth beneath the surface of the same liquid, and observing if the level remains constant.

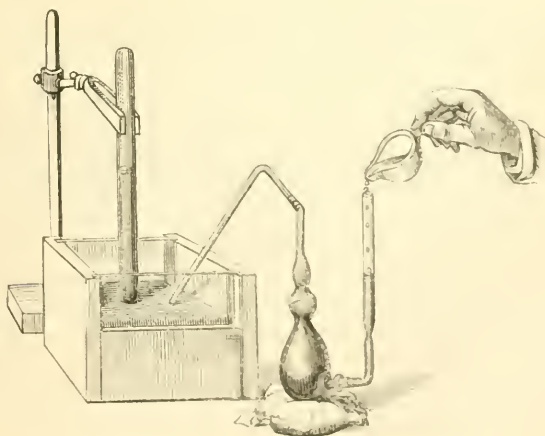
The joints having been thus proved perfect, the apparatus is filled with mercury and solution of potash, the delivery-tube is introduced, and the fire is extended to the organic mixture in the manner already described (Fig. 5). A slow but uninterrupted evolution of gas is kept up by gradually shifting back the screen and exposing a small quantity of the mixture at a time to the action of the fire. When the combustion has terminated, the unexhausted manganese at the sealed end of the tube is heated, and thus every trace of nitrogen is driven into the gas-apparatus. When the gas-bubbles which enter the potash are completely absorbed, the operation is at an end,

and the delivery-tube may be withdrawn from the apparatus. During the entire combustion the metallic copper in the fore-part of the tube must be kept at a full red heat.

Having thus collected all the nitrogen set free by the combustion of the organic compound, the next step is to transfer it to a eudiometer for measurement. This is done in the following manner:

A tube, of the shape represented in Fig. 8, which has been thick-
 FIG. 8. ened and has had its diameter considerably reduced at *A*, is fitted with a perforated cork, and firmly pressed into the mouth of the gas-vessel beneath the surface of the mercury. Care must be taken not to introduce air at the same time with the cork. This is best avoided by moistening it with a solution of corrosive sublimate previous to introduction. Mercury is now poured into the tube till its level there is considerably higher than that in the gas-vessel. The whole apparatus is then lifted out of the mercury, carried to a mercurial trough with glass sides, and allowed to stand for one or two hours, in order that the absorption of the carbonic acid may be complete. At the expiration of this time, a eudiometer similar to that employed in the preceding process (it is of course not necessary for it to be so long), is moistened with a drop of water, carefully filled with mercury, inverted and placed beneath the surface of the mercury in the trough. The end of the bent tube attached to the gas-apparatus is now brought under the eudiometer, the centre cord is removed from the caoutchouc, and mercury poured into the upright tube (Fig. 9). By this means the gas is gradually forced

FIG. 9.



into the eudiometer. When it is nearly all transferred, the mercury must be added, drop by drop, till the potash-solution makes its appearance in the bent tube above the caoutchouc, upon which the apparatus may be removed. Great care must be taken not to allow the mercury to carry down any air-bubbles into the apparatus. This is best prevented by filling the upright tube with mercury before detaching the cord, removing all air-bubbles with a copper wire, and afterwards, when the cord is untied, by pouring in mercury according as the gas is transferred, so as to keep it nearly full. This is readily done if the caoutchouc joint has been carefully made, so as not to allow the passage of gas without considerable resistance.

We have now transferred to the eudiometer the exact quantity of gas that was in the gas-apparatus. It is true that on beginning to transfer the nitrogen, the hair-tube was full of air, which was of course driven into the eudiometer; this is, however, exactly compensated by an equal measure of nitrogen remaining behind, namely, the full of the same hair-tube, on disconnecting the apparatus. We have thus been enabled, by means of this apparatus, and by the employment of a very small quantity of mercury, not only to transfer the gas completely to the eudiometer, but also to separate it completely from the potash-solution, which, by the tension of its vapour, would afterwards interfere with the accurate measurement of the gas.

The volume of gas is now read off and properly corrected for temperature, pressure, and aqueous vapour. The actual number of cubic centimetres it occupies and its weight, are afterwards ascertained by calculation.

The advantages of this method are :

1st. As in the preceding process, the complete combustion of the organic body is secured, and the formation of all oxides of nitrogen effectually prevented.

2nd. By employing the apparatus I have described, the accuracy of a gas measurement over mercury is secured, whereas in similar processes, the nitrogen has always been hitherto measured over water.

3rd. It is applicable to the analysis of almost all nitrogenous compounds, whether rich or poor in carbon or in nitrogen, and quite independently of the state in which the latter element may exist, whether as ammonia, amidogen, or in combination with oxygen.

4th. The process is very easy of execution, requires but a few hours for its completion, and contains within it remarkably few sources of inaccuracy.

I shall now give the results of the analyses that were made for the purpose of testing its accuracy.

NARCOTINE.

Quantity taken 0.5756 grm.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Corrected vol. at 0° C. and 760 ^{mm} pressure.	
Vol. of nitrogen (moist). . .	71.67	21.0	211.2 ^{mm}	754.2 ^{mm}	44.97 =
15.793 cub. cents. which weigh 0.1989 grm. = 3.45 per cent nitrogen.					

	Per cent. Theory.	Liebig.	Regnault.		Hofmann.
			1.	2.	
C ₄₆	64.61	64.09	64.01	64.50	64.53
H ₂₅	5.85	5.50	5.96	5.97	6.21
N	3.31	2.51	3.46	3.52	3.30
O ₁₁	26.23		26.57	26.01	25.96
	<u>100.00</u>				

MORPHIA.

Quantity taken, 0.5562 grm.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Corrected vol. at 0° C. and 760 ^{mm} pressure.	
Vol. of nitrogen (moist) . .	94.1	23.2	186.7 ^{mm}	744.3 ^{mm}	61.32 =
21.535 cub. cents. which weigh 0.027134 = 4.88 per cent nitrogen.					

	Per cent. Theory.	Liebig.	Regnault.		Will.	Dumas.
			1.	2.		
C ₃₄	71.57	72.34	72.87	72.41	72.50	72.02
H ₁₉	6.66	6.366	6.86	6.84	—	7.06
N	4.91	4.995	5.01	5.01	6.72	5.53
O ₆	16.86	16.299	15.26	15.74	—	14.84
	<u>100.00</u>					

The formula C₃₅ H₂₀ NO₆ gives 4.80 per cent nitrogen.

CODEINE.

Quantity taken, 0.5517 grm.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Corrected vol. at 0° C. and 760 ^{mm} pressure.	
Vol. of nitrogen (moist) . .	88.04	20.7	197.3 ^{mm}	745.6 ^{mm}	56.88 =
19.976 cub. cents. which weigh 0.02517 = 4.56 per cent nitrogen.					

	Per cent. Theory.	Regnault.		Gerhardt.
		1.	2.	
C ₃₅	72.24	74.32	73.94	73.30
H ₂₁	7.02	7.19	7.23	7.19
N	4.67	4.89	4.86	4.89
O ₆	16.07	13.60	13.94	14.62
	100.00			

This formula, which is Gerhardt's, has been recently confirmed by Dr. Anderson.*

NICOTINE.

In order to secure its being perfectly anhydrous, I heated it in an oil-bath to 149° C. and maintained it at this temperature for upwards of an hour, a stream of dry hydrogen gas being passed through it at the same time.

A slight modification of the process becomes necessary, in order to adapt it to the analysis of fluids. The manganese is introduced into the combustion-tube, and then an asbestos plug as usual. A second plug is now placed at a distance of about 3 inches from the first, an empty space being left between them. A glass bulb is now made with a long neck and a hair-bore, and weighed. With the exception of the neck, it is completely filled with the fluid intended for analysis, sealed, and weighed again. A little oxide of copper is next introduced into the tube, then the bulb with the point broken off, and finally more oxide, till the neck is half covered. A mixture is now made of 15 parts of oxide of copper and 10 parts of oxide of mercury. Of this a quantity is weighed out, sufficient to furnish 8 grms. for every decigramme of fluid employed in the analysis, and transferred to the tube, of which it should occupy 8 or 10 inches. Some unmixed oxide of copper is next added, sufficient to form a stratum of 3 inches in length, and the remainder of the tube is filled as before. It is now arranged on the furnace, and the manganese is heated as usual, the bulb being kept quite cold during the passage of the gas. The metallic copper and oxide are next heated, and the fire is extended to the mixture, a small quantity of which is heated, a red-hot coal being at the same time brought near the bulb. The fire is gradually extended back to the bulb, which should be heated so as to produce a slow but constant evolution of gas. The remainder of the process is conducted as before.

* Chem. Soc. Qu. J. III, 112.

When a very volatile fluid is to be analyzed, it is advisable to employ a retort to contain the manganese.

Quantity taken, 0.3312 gm.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 760 ^{mm} pressure.
Vol. of nitrogen (moist) . .	170.51	19.7	112.0 ^{mm}	744.9 ^{mm}	128.38 =

45.087 cub. cents. which weigh 0.056809 = 17.15 per cent nitrogen.

	Per cent.	Theory.	Barral.	Melsens.
C ₁₀	73.17		73.33	74.3
H ₈	9.76		9.42	8.8
N	17.07		17.04	17.3
	100.00			

The formula C₁₀ H₇ N gives 17.28 per cent nitrogen.

NITRATE OF POTASH.

In this analysis I employed a shorter combustion-tube and less manganese. 0.5033 gm. of the nitrate, which had been previously rendered anhydrous, was weighed out, and, in order to secure complete decomposition, mixed in a mortar with 1½ grms. of perfectly dry bisulphate of potash. 12 grms. of a mixture of equal parts of oxide of copper and oxide of mercury were now added, and the whole well rubbed up together. This was transferred to the tube, and the remainder of the analysis conducted as before.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 760 ^{mm} pressure.
Vol. of nitrogen (moist) . .	200.17	22.3	84.6 ^{mm}	743.2 ^{mm}	154.89 =
54.397 cub. cents. which weigh 0.0685402 gm. = 13.62 per cent					
Theory = 13.83					,,

CHLORIDE OF AMMONIUM.

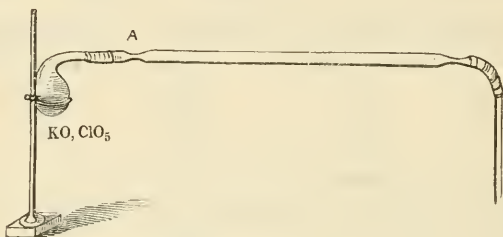
In this analysis also a shorter tube and less manganese were employed.

Quantity taken, 0.3101 gm.

	Observed vol.	Temp. C.	Height of mercury above that in trough.	Barom.	Corrected vol. at 0° C. and 760 ^{mm} pressure.
Vol. of nitrogen (moist) . .	228.37	22.7	56.5 ^{mm}	744.8 ^{mm}	184.51 =
64.799 cub. cents. which weigh 0.8164 gm. = 26.32 per cent					
Theory = 26.21					,,

These analyses leave little more to be desired. I believe, however, that by a very slight modification of the process, results almost absolutely accurate might be obtained. Instead of being sealed at one end, the combustion-tube is drawn out, and made so fine at *A* (Fig. 10) as to be readily fused with a mouth blowpipe.

FIG. 10.



This end is connected, by means of a cautchouc joint, with a small retort containing chlorate of potash, and the tube is filled exactly as before. It is now drawn out in front also, and a narrow delivery-tube, 30 inches in length, attached to it. It is then placed on a furnace, the end of the delivery-tube plunged beneath the surface of mercury, and the chlorate heated, by means of a lamp, for a quarter of an hour. At the expiration of this time, the lamp is removed, a small quantity of the metallic copper in the fore-part of the tube is heated, and the heat continued till the height of the mereury in the delivery-tube nearly corresponds with that of the barometer. A high temperature is by no means necessary to enable copper to absorb the oxygen, and it should be avoided. As soon as the mercury has ceased to rise in the delivery-tube, the coals are removed from the copper, and when it is nearly cold, the chlorate is once more heated for a quarter of an hour, and afterwards a fresh quantity of the metallic copper as before. When the mereury has risen a second time to the height of the barometer, the combustion-tube is sealed at *A*, and the retort is removed. The manganese is now heated, and the rest of the analysis conducted exactly as before, with this exception, that the potash solution must be saturated with nitrogen or air previous to its introduction into the gas-apparatus.

This modification I have not had time to test by experiment; but hope shortly to be able to do so. I believe it might be also applied with good effect to ths Comparative Method.

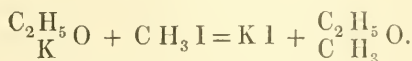
This investigation was conducted in the laboratory of Professor Bunsen, in Heidelberg. Before concluding, I cannot deny myself the pleasure of expressing my gratitude to him for his great personal kindness and valuable advice during the progress of the research.

XXIII.—On *Ethers intermediate between the Enanthylic and the Methylic, Ethylic, and Amylic Series, and on the constitution of Castor-oil Alcohol.*

By A. W. WILLS,

OF UNIVERSITY COLLEGE, LONDON.

Dr. Williamson* has shown that alcohols may be regarded as water $\begin{smallmatrix} \text{H} \\ \text{H} \end{smallmatrix} \text{O}$, in which 1 atom of hydrogen is replaced by an organic radical, methyl, ethyl, &c., and ethers as water in which both atoms of hydrogen are thus replaced; *e. g.*, vinic alcohol = $\begin{smallmatrix} \text{C}_2\text{H}_5 \\ \text{H} \end{smallmatrix} \text{O}$; † vinic ether = $\begin{smallmatrix} \text{C}_2\text{H}_5 \\ \text{C}_2\text{H}_5 \end{smallmatrix} \text{O}$. Moreover, he has shown that by acting on potassium-alcohol $\begin{smallmatrix} \text{C}_2\text{H}_5 \\ \text{K} \end{smallmatrix} \text{O}$ by the iodides of methyl, amyl, &c., intermediate ethers may be formed, containing different radicals; thus, with potassium-alcohol and iodide of methyl:



The object of the following experiments is to show that similar intermediate ethers may be formed, containing the radical *Enanthyl*, $\text{C}_7 \text{H}_{15}$, together with methyl, ethyl, &c.

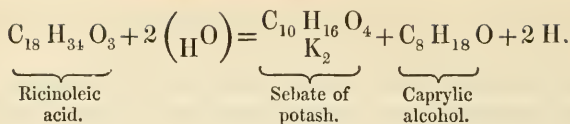
CASTOR-OIL ALCOHOL.

Previously to forming these ethers, some time was occupied in experiments upon the constitution of castor-oil alcohol, this substance possessing considerable interest, from its important position in the series to which it belongs, viz., probably between the caproic and caprylic alcohols. It was discovered by M. Bouis, who believed it to be caprylic alcohol $\text{C}_8 \text{H}_{18} \text{O}$, and explained its formation, in the distillation of castor-oil with potash, by the following equation: ‡

* Phil. Mag. [3] XXXVII, 60; Chem. Soc. Qu. J. IV, 106.

† The atomic weights used in this paper are those of Gerhardt, viz. H=1; O=16; S=32; C=12; Cl=35.5; I=126; K=39; Na=23, &c. (*Vid.* Gmelin's Handbook, Translation, VII, 17.)

‡ Compt. rend. XXXII, 141; Chem. Soc. Qu. J. IV, 362.



It was subsequently announced that M. Bouis had, upon further investigation, come to the conclusion that the substance in question was not caprylic but œnanthylic alcohol, $C_7 H_{16} O$.*

The alcohol used in my experiments was prepared by saponifying pure castor-oil by solution of potash; separating the soap by addition of common salt; fusing the hard mass with about $\frac{1}{3}$ of its weight of solid hydrate of potash till a distinct smell of the alcohol was perceptible, in order to expel water; and, finally, distilling the mixture in charges of 5 or 6 lbs. in a copper retort.

At each distillation, about $\frac{1}{2}$ pint of turbid watery liquid came off, smelling of the alcohol, and then 9 or 10 oz. of the crude alcohol itself; care being taken to avoid the formation of empyreumatic products from decomposition of the sebate of potash at the end of the operation.

The crude oily product was then redistilled fractionally, and the parts having different boiling-points separated by a thermometer.

At the end of the operation, there remained in the retort a small quantity of yellow oily liquid, not volatile without decomposition, becoming solid on cooling, and perfectly neutral to test-paper.

The larger part of the alcohol was thus brought to the constant boiling-point of 178°C. ; and in three several preparations of the substance, the same point was obtained; nor could any large portion be reduced below this point by repeated fractional distillation, a comparatively small quantity only coming over at points between 172° and 178° and above the latter degree.

Thus formed, castor-oil alcohol is a colourless, oily liquid, burning with a clear bright flame, of peculiar odour; boiling at 178° ; of spec. grav. 0.792 at $16^\circ.5 \text{ C.}$; insoluble in water, soluble in alcohol and ether.

The mean of several combustions closely agreeing, gave per cent :

C 72.787

H 13.669

O 13.544

Theory requires for the formula of œnanthylic alcohol, per cent :

* Instit. 1853, 257.

C	72.41	giving errors of	+0.37
H	13.79	„ „	—0.12
O	13.80	„ „	—0.24

while the numbers required for the formula of caprylic alcohol are per cent :

C	73.84
H	13.84
O	12.32

The above results appeared, therefore, to confirm the fact that the castor-oil alcohol so obtained was œnanthylic, not caprylic alcohol.

Its calculated boiling-point, taking the difference for each variation in composition by CH_2 as $19^\circ.5$ C. would be $175^\circ.9$, while that of caprylic alcohol would be $195^\circ.4$, the boiling-point of vinic alcohol being $78^\circ.4$.

As analyses and vapour-densities had been obtained by Mr. Railton, from alcohol prepared in an exactly similar manner to that which I have described and from the same samples of castor-oil, closely agreeing with the results required by theory for œnanthylic alcohol,* I did not pursue the subject further, but proceeded to form the ethers which I shall describe.

The fact that they were obtained, is in itself sufficient proof that the substance employed in their formation was the 14-carbon alcohol.

Since these experiments were made, Moschnin has obtained different results, tending to prove that the castor-oil alcohol is in reality caprylic, this view being supported by combustions and atomic weights of the baryta-salt of the conjugate sulphuric acid.†

I regret that I have not as yet had the opportunity of seeking all the confirmation I could desire of the above results. Combustions have been made, however, of several portions of liquid, prepared as above, and of various boiling-points.

A part having the fixed boiling-point 173° to 174° C., gave the following percentage :

C	71.83
H	12.37
O	15.83

* Chem. Soc. Qu. J. VI, 205.

† Ann. Ch. Pharm. LXXXVII, 111 ; Chem. Gaz. Nov. 15, 1853.

Theory requires for $C_7H_{16}O$:

	Errors
72·41	—0·58
13·79	—1·42
13·80	+2·04

A portion boiling at 175° to $175^\circ\cdot5$ gave :

C	72·16	showing errors of	—0·25
H	13·42	„ „	—0·37
O	14·42	„ „	+0·63

From these figures it might be expected that the boiling-point of the pure substance would lie between 175° and 178° , while it is somewhat remarkable that a very small portion was obtained between these points.

Most of the analyses were performed immediately after the distillation of the liquids, but no such change occurred by standing as that mentioned by Moschnin. All the combustions were made with oxide of copper and a stream of oxygen gas.

An attempt was made to form the pure baryta-salt of the corresponding acid, by acting upon the alcohol with equivalent quantities of bichromate of potash and sulphuric acid, distilling off nearly to dryness, neutralizing by hydrate of baryta, again distilling to remove alcohol, and crystallizing after removal of excess of baryta by carbonic acid and subsequent boiling. The pearly crystalline scales obtained after slight evaporation were removed, pressed between folds of blotting-paper and dried *in vacuo*. By further evaporation, a second crystallization was obtained, and in a similar manner four crops were produced.

The determination of the atomic weights of the first two and the last, proved that the acidified portions had taken up too much oxygen and had been partially converted into acids lower in the series than the one sought; as indeed would appear to be necessarily the case, from the fact of a considerable portion of alcohol remaining unoxidized, although all the chromate of potash appeared to have been reduced.

The percentages of baryta were :

1st salt.	2nd ditto.	4th ditto.
39·57	41·03	42·95

Enanthylate of baryta contains per cent 38·76; caproate of baryta, the next term in the series, 41·71. It seems doubtful how far this

method of oxidation is adapted to the production of pure acids, although capable of effecting the acidification of large quantities of alcohols very readily.

Vapour-densities of the alcohol were also determined, but were uniformly found considerably higher than is required by theory, the mean of several experiments being 4.57.

This result would lead to the same conclusion as that of the combustions (in which there was a slight excess of carbon and deficiency of hydrogen), viz. : that the alcohol was contaminated with some substance more highly oxidized, probably formed by the decomposition of the sebate of potash; and this supposition is confirmed by the fact, that in forming one of the ethers, a body was eliminated, of higher and more uncertain boiling-point, and containing also a higher percentage of carbon; in fact, of such a constitution as might arise from the treatment of such a body as the one alluded to.

An attempt was also made to form iodide of œnanthyl, by the alternate action of iodine and phosphorus upon the alcohol, until solid iodide of phosphorus was deposited. The dark liquid produced was heavier than water, and when washed and distilled from lime and mercury, began to boil at 126° C., from which it rose quickly to 191° or 192° , at which point the greater part came over. The distillate was colourless while hot, but became dark upon cooling. Redistilled from chloride of calcium, it came over as before, mostly at 191° to 192° .

Another portion, similarly prepared, was washed with dilute carbonate of soda, then boiled with solution of potash to decompose hydriodic acid, &c., and distilled off chloride of calcium. The distillate was decolourized by a very small fragment of phosphorus, again washed with potash and placed over sulphuric acid to dry. It had a somewhat higher boiling-point than the former portions, viz. about 196° .

Taking the boiling-point of iodide of ethyl as 73° C., and that of iodide of amyl as 146° , the calculated point of iodide of œnanthyl would be $194^{\circ}.5$.

Although no difference has hitherto been recognized between samples of castor-oil from different sources, it seems probable either that such a difference really exists, and hence that the products obtained by its treatment may be characterized by a corresponding variation, or that, according to the manner of operation, especially in regard to the quantity of alkali used in saponification and distillation, sometimes one alcohol, sometimes the other, or possibly a mixture of the two may be obtained, together with occasional products of a different

constitution. And it may here be observed, that both Bouis and Moschnin employed a process somewhat different from that described in this paper, inasmuch as they heated the oil directly with potash, without previous saponification.

It is difficult to avoid this conclusion when we observe that M. Bouis himself arrived, in a first examination, at the formula for the higher, and in a second at that for the lower alcohol, and when a like discrepancy is seen in the results of other experimenters.

NINE-CARBON ETHER; ETHYL-ÆNANTHYL ETHER, $\begin{matrix} \text{C}_2\text{H}_5 \\ \text{C}_7\text{H}_{15} \end{matrix} \text{O}.$

It was first attempted to form this ether by acting on sodium-ænanthyl alcohol $\begin{matrix} \text{C}_7\text{H}_{15} \\ \text{Na} \end{matrix} \text{O}$, by iodide of ethyl, as long as any action ensued, and removing the last traces of alcohol by sodium; but it was found that the decompositions which occurred were indefinite; the continued action of sodium being, in fact, shown by analysis to deoxidize the alcohol or ether, and to give rise to substances containing a smaller percentage of oxygen than either of the former, as is evident from the following figures.

	A.			B.	C.	Theory requires for $\text{C}_9\text{H}_{20}\text{O}$.
	1.	2.	Mean.			
C	74.44	74.37	74.40	76.81	76.65	75.00
H	13.66	13.34	13.50	14.70	16.42	13.88
O	11.89	12.28	12.09	8.48	6.92	12.11

A. being figures obtained by analysis of a portion of liquid obtained as above, of boiling-point 175° to 176° C.

B. by that of the same liquid after long action of potassium upon it.

C. by the combustion of a similar portion after more prolonged action.

It was thought possible, that by very long action, the hydrocarbon C_7H_{14} , or the intermediate hydrocarbon C_9H_{18} , might be produced; but after some hours, the action became sluggish, and would probably have ceased entirely before the desired effect was nearly produced.

The action by indefinite quantities of the several materials, failing therefore to produce the required body in a state of exact purity, the experiment was repeated with *equivalent* quantities of ænanthyl

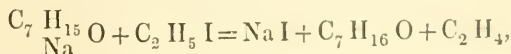
alcohol, sodium, and iodide of ethyl. The latter was prepared in the ordinary way, by the action of phosphorus and iodine on absolute alcohol, and had a boiling-point of 73°C . Half the alcohol was first acted upon by half the sodium, and then half the iodide added and slight heat applied. Much iodide of sodium was deposited, and the smell of the iodide ceased. More sodium and iodide were then added, in small portions at a time, the former acting with difficulty, but the action being renewed upon removal of the sodium and addition of a little more iodide. When the latter was accidentally added in excess, small quantities of fresh material were taken, also in equivalent weights, and the sodium-alcohol they supplied was added in excess to the mixture previously containing excess of iodide of ethyl.

The action being completed, the liquid was distilled off from the residue of iodide of sodium, without using potassium to remove traces of alcohol, and introduced into a small retort, from which it was distilled fractionally with a thermometer.

It began to boil at 137° or 138°C ., and rose quickly to 177° , at which point the larger part came over, a small portion only passing above this point.

The liquid so obtained was colourless and mobile, having the peculiar generic smell of all ænanthyl compounds, although distinct from that of the alcohol; it burns with a clear luminous flame, is insoluble in water, soluble in ether and alcohol; boils at 177°C ., and its spec. grav. is $0\cdot791$ at 16° .

The close correspondence of this body with the alcohol in boiling-point and specific gravity, suggested the possibility of the following transformation having taken place, although there were no signs of its occurring, such as evolution of olefiant gas:



the ether $\text{C}_9 \text{H}_{20} \text{O}$ being in fact resolved into the alcohol and olefiant gas; but combustions proved it to be really the ether.

$0\cdot2279$ gram. of liquid gave $\text{HO} = 0\cdot2968$ and $\text{CO}_2 = 0\cdot6281$, corresponding to:

Per cent.	Theory requires for formula $\text{C}_9 \text{H}_{20} \text{O}$.
C 75·16	75·00
H 14·44	13·88
O 10·38	11·11

In taking the specific gravity of the vapour of this substance, and in all similar experiments, the globes were filled with dry hydrogen previously to introduction into the oil-bath, in the manner described by Mr. Railton,* in order to prevent the blackening and oxidation of the substance, which otherwise takes place at the high temperature necessarily employed in the experiment.

The following results were obtained :

Weight of globe full of dry air at 21° C. and bar.

29·72 in. 76·5009 grms.

Globe sealed at 242° C. and bar. 29·73 in.

Globe with condensed vapour at 20° C. and bar.

29·73 in. 77·2740 „

Capacity of globe 22·1 cub. in.

Residual hydrogen at 21° C. and bar 29·73 in. 0·2 „

These figures give as the spec. grav. 5·095 ; calculation gives 4·998 ; error, ·097.

EIGHT-CARBON ETHER ; METHYL-CENANTHYL ETHER, $\begin{smallmatrix} \text{C} & \text{H}_3 & \text{O} \\ \text{C}_7 & \text{H}_{15} & \end{smallmatrix}$

This ether was prepared in a manner strictly analogous to that employed in forming the 9-carbon ether. The iodide of methyl used had the boiling-point 43° C.

After each addition of iodide, the liquid was distilled off in an oil-bath from the iodide of sodium deposited, and then the whole fractionally distilled.

A small portion came off below 154° C., smelling of iodide of methyl ; the boiling-point then rose steadily to 161°·5, between which point and 162°·5, most came over ; thence to 164°—166°.

The part boiling at 161°·5 to 162°·5 was redistilled over a spirit-lamp, and came over almost entirely at 161°—162° ; a little at 162°—163°.

The small portion coming over first at 162° to 164° also yielded a portion at 161°—162°, most remaining at the same points as before.

The entire portion boiling at 161°—162° was now distilled upwards with a small fragment of sodium, in order to destroy the last traces of alcohol. A slight action ensued upon the application of a gentle heat ; and when this had ceased, the liquid was distilled off at 160°·5—161°, except a few drops only above that point.

* Chem. Soc. Qu. J. VI, 205.

It is a colourless, mobile body, of strong smell, insoluble in water, soluble in alcohol and ether; of boiling-point $160^{\circ}\cdot 5$ — 161° , and of spec. grav. 0·830 at $16^{\circ}\cdot 5$.

For some reason, I found unusual difficulty in burning this body, even with a stream of oxygen, a difficulty the cause of which is not apparent from the constitution of the substance.

The following were the results of analyses :

I.	0·1890	gram.	ether	gave	CO ₂	0·5078	and	HO	0·2423
II.	0·1534	„	„	„	„	0·4118	„	„	0·1924
III.	0·1098	„	„	„	„	0·2949	„	„	0·1427

Corresponding to per cent :

	I.	II.	III.	Mean [omitting (H, III)].
C	73·280	73·213	73·251	73·248
H	14·243	13·930	(14·422)	14·086
O	12·477	12·857	12·327	12·666

It appears from these figures, that the substance obtained was the ether sought, but not in a state of complete purity, for theory requires for the formula $C_8H_{15}O$, per cent :

C	73·846
H	13·846
O	12·308

A portion of the liquid obtained in the above process, of boiling-point 162° — 164° , was also analyzed and gave per cent :

C	74·72
H	13·68
O	11·48

It was to this substance that allusion was made, as perhaps affording some clue to the nature of the impurities contaminating the alcohol.

It appears, therefore, that the portion obtained with the constant boiling-point of $160^{\circ}\cdot 5$ — 161° C. is the one most nearly approaching to purity; and the fact is confirmed by the vapour-densities obtained, which are all somewhat below that required by theory.

The following were the results, the globes being sealed respectively at $217^{\circ}\cdot 5$ and 223° C.

Boiling-point of liquid, 160°·5—161° C.

I.	II.	Mean.
4·23	4·18	4·20

Theory requires 4·48, and the error occurs on the same side as that in the combustions, viz., as resulting from a lower percentage of carbon than that corresponding to the theoretical composition.*

There is no doubt, however, that the substance is the intermediate ether $\text{C}_7\text{H}_{15}\text{O}$, in a state approaching purity.

TWELVE-CARBON ETHER; AMYL-ÆNANTHYL ETHER, $\text{C}_5\text{H}_{11}\text{O}$, C_7H_{15} .

In forming this ether, equivalent quantities of ænanthylic alcohol, iodide of amyl, of boiling-point 146° C., and of sodium, were taken, and a process employed analogous to that used in forming the 8- and 9-carbon ethers.

Much iodide of sodium was deposited, but the liquid, when re-distilled, gave no large portion with a fixed boiling-point; it seemed most constant about 210° C. The process was therefore repeated on a larger scale; and the liquid obtained, when fractionally distilled, began to boil at 152°, and rose gradually to 177°, between which point and 180°, a good deal, apparently of undecomposed alcohol, came over. Thence the boiling-point rose to 219° or 220°, and remained stationary for some time at 220° to 221°; the last portions then rapidly rose to 230° and above.

The portion boiling at 220° to 221° C., was a colourless, mobile liquid, of strong odour and burning taste, soluble in ether and alcohol, but not in water; burning with a clear bright flame, volatile without decomposition, and of spec. grav. 0·608 at 20° C.

The calculated boiling-point of this ether (taking that of $\text{C}_8\text{H}_{18}\text{O}$ as 161°, and that of $\text{C}_9\text{H}_{20}\text{O}$ as 177°) would be 225°.

Combustions gave per cent :

C	76·99
H	13·78
O	9·23

* Two experiments gave as the density of the vapour of the portion boiling at the higher point, the numbers 4·70 and 4·77, the globes being sealed at 234° and 214° C. respectively.

Theory requires.		Error.
C	77.42	-0.42
H	13.97	-0.19
O	8.61	+0.62

This result is confirmed by the vapour-density, which was found to be 6.57, while calculation gives 6.47.

An attempt was also made to form this ether by the mutual action of equivalent quantities of amylic and cœnanthylic alcohols, together with enough sulphuric acid to convert the latter into sulphœnanthylic acid; but it was not attended with success, the application of a very moderate heat producing blackening and decomposition, and no etherification occurring at the temperature which it was possible to apply without producing this effect.

In conclusion, I take this opportunity of expressing my obligation to Dr. Williamson for his advice and assistance during the progress of these experiments.

PROCEEDINGS
AT THE
MEETINGS OF THE CHEMICAL SOCIETY.

November 7, 1853.

WARREN DELARUE, Esq., in the Chair.

The following donations were announced :

"The Quarterly Journal of the Geological Society:" from the Geological Society.

"The Literary Gazette" for July, August, September, and October : from the Publishers.

"Bulletin de la Société Vandoise des Sciences Naturelles," No. 1.

The following communications were read :

"On the Constitution of Salts considered as Substitution-products formed on the Type of Water," by Dr. Odling.

"On New Methods for the determination of Nitrogen in organic and inorganic Compounds," by Dr. Maxwell Simpson.

November 21, 1853.

ROBERT PORRETT, Esq., Treasurer, in the Chair.

The following donations were announced :

"The Transactions and Proceedings of the Royal Society of Edinburgh, for the session 1852-3:" from the Society.

"The Literary Gazette."

"The Journal of the Society of Arts."

"The Journal of the Photographic Society."

"The Medical Circular."

"Taylor's Calendar of Scientific Meetings:" from the Publishers.

"Hand-book of Chemistry," by Messrs. Abel and Bloxam: from the Authors.

G. Downing Living, Esq., of St. John's College, Cambridge, was duly elected a Fellow of the Society.

A Paper was read:

"On Ethers intermediate between the *Ænanthylie* and the *Ethylie*, *Methylie*, and *Amylic* series:" by A. W. Wills.

December 5, 1853.

COLONEL PHILIP YORKE, President, in the Chair.

The following donations were announced:

"Bulletin de la Classe Physico-mathématique de l'Académie Impériale des Sciences de St. Pétersbourg."

"The Pharmaceutical Journal, for December:" from the Editor.

"The Literary Gazette," 2 numbers.

"The Medical Circular," 2 numbers: from the Publishers.

The following Papers were read:

"Analysis of the Ash of Lemon-juice," by Henry M. Witt.

"On the Platino-tersulphocyanides and the Platino-bisulphocyanides, two new series of salts, and their decompositions:" by George Bowdler Buckton, F.L.S.

December 19, 1853.

COLONEL PHILIP YORKE, President, in the Chair.

The following donations were announced:

"The Literary Gazette:" from the Publishers.

"The Journal of the Society of Arts:" from the Society.

"The American Journal of Science and Arts," by Professors Silliman and Dana: from the Editors.

"List of Members of the Royal Institution of Great Britain."

"Notices of Meetings of the Royal Institution:" from the Royal Institution.

"Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften," Vienna. Band x, Heft 4 & 5.

"Denkschriften der Kaiserlichen Akademie der Wissenschaften." Fünfter Band. Zweite Lieferung.

Ditto. Vierter Band. Erste Lieferung.

Tafeln zur Abhandlung.

"Beiträge zur Naturgeschichte von Chili," von Freiherrn v. Bibra.

"Proceedings of the Royal Society," from the Society.

Bronze Medal of Berzelius: from Dr. N. P. Hamberg, of Stockholm.

The following Papers were read:

"Note on Platinum accompanying Silver in solution in Nitric Acid," by Henry How.

"Note on the Valuation of Protochloride of Tin," by Dr. Penny.

"On the so-called Iodide and Chloride of Nitrogen," by J. H. Gladstone, Ph.D., F.R.S.

TITLES OF CHEMICAL PAPERS

IN

BRITISH AND FOREIGN JOURNALS,

PUBLISHED IN THE YEAR 1853.

A.

Acetates.—On the acetates and other compounds of alumina: by *Walter Crum*. Chem. Soc. Qu. J. vi, 217.

Acetimetry.—On acetimetry: by *C. G. Williams*. J. Pharm. [3] xxiv, 288.

Acetone.—Chemical examination of acetone: by *G. Städeler*. Nachr. von der Gesellsch. d. Wiss. zu Göttingen, 1853, No. 9, p. 121; Chem. Gaz. 1853, 341.

— On the presence of methylamine in the products accompanying acetone: by *C. G. Williams*. Chem. Gaz. 1853, 409.

Acid, Acetic.—New process for manufacturing pure acetic acid: by *Christl and Völckel*. Chem. Gaz. 1853, 96.

.. .. New method of manufacturing pure acetic acid. Pharm. J. Trans. xiii, 176.

Anthranilic.—On anthranilic, benzamic, and carbanilidic acids: by *B. W. Gerland*. Ann. Ch. Pharm. lxxxvi, 143.

Arsenious.—On arsenious acid, its salts, and the arsenio-sulphides: by *O. B. Kühn*. Arch. Pharm. cxix, 267, and cxxi, 1; Chem. Gaz. 1853, 364.

.. .. On compact transparent sulphur and vitreous arsenious acid: by *C. Brame*. Ann. Ch. Phys. [3] xxxvii, 217.

.. .. On vitreous arsenious acid: by *C. Brame*. Comp. rend. xxxvii, 90.

Boracic.—On the influence of water on boracic acid in borates: by *H. Rose*. Chem. Gaz. 1853, 65.

.. .. On the compounds of boracic acid and water with protoxide of cobalt, protoxide of nickel, and oxide of zinc: by *H. Rose*. Pogg. Ann. lxxxviii, 299.

.. .. On the compounds of boracic acid and water with sesquioxide of iron: by *H. Rose*. Pogg. Ann. lxxxix, 473.

.. .. On the compounds of boracic acid and water with oxide of copper: by *H. Rose*. Pogg. Ann. lxxxvii, 598.

.. .. On the compounds of boracic acid and water with oxide of lead: by *H. Rose*. Pogg. Ann. lxxxvii, 470.

.. .. On the compounds of boracic acid and water with oxide of silver: by *H. Rose*. Pogg. Ann. lxxxviii, 482.

.. .. Action of boracic acid on tincture of litmus: by *Malaguti*. Ann. Ch. Phys. [3] xxxvii, 206.

- Acid, Boracic.—Note on the existence of boracic acid in several mineral waters and in various natural substances : by *E. Filhol*. Compt. rend. xxxvi, 327 ; Chem. Gaz. 1853, 113.
- On the presence of boracic acid in the mother-liquor of the salt-springs of Bex : by *M. Baup*. J. Pharm. [3], xxiii, 43.
- On the presence of boracic acid in the alkaline, sulphureous, thermal waters of Olette (Pyrénées Orientales) : by *J. Bouis*. Compt. rend. xxxvi, 229.
- On the presence of boracic acid in the mineral waters of Wiesbaden and Aix-la-Chapelle : by *Fresenius* and *Wildenstein*. J. pr. Chem. lv, 163 ; J. Pharm. [3] xxiii, 76.
- Camphomethylic.—On camphomethylic acid : by *A. Loir*. Ann. Ch. Phys. [3] xxxvii, 196 ; xxxviii, 483.
- Camphoric.—On lævo-camphoric acid and lævocamphor : by *J. Chautard*. Compt. rend. xxxvii, 166.
- Caproic.—Note on the preparation of propionic and caproic acids : by *A. W. Williamson*. Phil. Mag. [4] vi, 204.
- Caprylic.—On anhydrous caprylic acid : by *L. Chiozza*. Compt. rend. xxxv, 865 ; Ann. Ch. Pharm. lxxxv, 229 ; Chem. Gaz. 1853, 88.
- Carbonic.—Action of carbonic acid on tincture of litmus : by *J. Malaguti*. Ann. Ch. Phys. [3] xxxvii, 206.
- Apparatus for the determination of carbonic acid : by *Max. Scheffner*. Chem. Gaz. 1853, 37.
- Action of carbonic acid on quinine and cinchonine ; formation of crystallized carbonate of quinine : by *M. Langlois*. Compt. rend. xxxvii, 727.
- Note on an apparatus for estimating carbonic acid : by *M. de Luca*. Compt. rend. xxxvii, 730.
- Citric.—Researches on the fermentation of citric acid : by *J. Personne*. Compt. rend. xxxvi, 197 ; Chem. Gaz. 1853, 147.
- Improvements in the manufacture of citric and tartaric acid (Price's Patent). Pharm. J. Trans. xiii, 46.
- Formic.—On the presence of formic acid in the human secretions : by *D. Campbell*. Chem. Gaz. 1853, 310.
- Fumaric.—On the occurrence of fumaric acid in *Corydalis bulbosa* : by *W. Wicke*. Ann. Ch. Pharm. lxxxvii, 225.
- Gallic.—On the preparation of gallic acid from Chinese gall-nuts : by *G. C. Wittstein*. Pharm. J. Trans. xii, 444.
- Hippuric.—Reproduction of hippuric acid : by *M. Dessaignes*. Compt. rend. xxxvii, 251 ; Ann. Ch. Pharm. lxxxvii, 325.
- Hydrochloric.—Volumetrical determination of sulphuric and hydrochloric acid : by *M. Levol*. Chem. Gaz. 1853, 378.
- Hydrocyanic.—Determination of the strength of hydrocyanic acid : by *J. Robertson*. Pharm. J. Trans. xiii, 105.
- On the estimation of iron, cyanogen, hydrocyanic acid, and hydrosulphocyanic acid by volume analysis ; and on the quantitative determination of the sulphocyanide of potassium in saliva : by *T. J. Herapath*. Chem. Gaz. 1853, 294.
- Hydroferrocyanic.—Preparation of hydroferrocyanic acid. Ann. Ch. Pharm. lxxxvii, 127.

- Acid, Hydrofluoric.—On the preservation of hydrofluoric acid: by *G. Städeler*. *Ann. Ch. Pharm.* lxxxvii, 137.
- Hydrosulphuric.—On the action of sulphuretted hydrogen on picric acid: by *A. Girard*. *Compt. rend.* xxxvi, 421.
- Kyanurenic.—On kyanurenic acid: by *J. Liebig*. *Chem. Soc. Qu. J.* vi, 112; *Ann. Ch. Pharm.* lxxxvi, 125; *Ann. Ch. Phys.* [3] xxxviii, 488.
- Meconic.—On meconic acid and its derivatives: by *H. How*. *Ed. Phil. Trans.* xx, pt. 3, 401; *abstr. Chem. Soc. Qu. J.* vi, 72.
- Moritannic.—On the formula of moritannic acid: by *R. Wagner*. *Chem. Gaz.* 1853, 175.
- Nitric.—On the preparation of chemically pure nitric acid, and of the nitrates of potash and soda: by *C. Weber*. *Pharm. J. Trans.* xii, 596.
- On the manufacture of nitric acid. *Pharm. J. Trans.* xii, 428.
- On nitric acid as a source of the nitrogen found in plants: by *G. Wilson*. *Trans. Roy. Soc. Edinb.* xx, 591.
- Were the ancient Egyptians acquainted with nitric acid? by *T. J. Herapath*. *Phil. Mag.* [4] v, 339.
- On the supposed conversion of ammonia into nitric acid in the animal organism: by *C. Jaffé*. *Pharm. J. Trans.* xiii, 232.
- New test for nitric acid and the nitrates: by *E. W. Davy*. *Phil. Mag.* [4] v, 330; *J. Pharm.* [3] xxiv, 205.
- Oleic.—Purification of oleic acid and application to manufacturing purposes (*Wilson's Patent*). *Pharm. J. Trans.* xii, 551.
- Oxalic.—On the volumetric determination of oxalic acid: by *F. Liesching*. *Chem. Gaz.* 1853, 472.
- Oxylizariac.—On oxylizariac acid (purpurin): by *H. Debus*. *Ann. Ch. Pharm.* lxxxvi, 117.
- Paracitric.—On paracitric acid and the paracitrates: by *F. L. Winckler*. *Jahrb. f. pr. Pharm.* xxv, 65; *Chem. Gaz.* 1853, 32.
- On the identity of Winckler's paracitric acid with malic acid: by *L. Pasteur*. *J. Pharm.* [3], xxiv, 75.
- Pelargonic.—On anhydrous pelargonic acid: by *L. Chiozza*. *Compt. rend.* xxxv, 865; *Ann. Ch. Pharm.* lxxxv, 231; *Chem. Gaz.* 1853, 88.
- On a compound of pelargonic acid with nitric oxide: by *L. Chiozza*. *Ann. Ch. Pharm.* lxxxv, 225; *Chem. Gaz.* 1853, 123.
- Permanganic.—On permanganic acid. *Ann. Ch. Pharm.* lxxxvi, 373.
- Phosphoric.—On the apparent volatilization of phosphoric acid from acid solutions, and on the action of hydrochloric acid on phosphate of soda: by *R. Fresenius*. *Ann. Ch. Pharm.* lxxxvi, 216.
- Estimation of phosphoric acid and the phosphates by means of nitrate of uranium: by *M. Leconte*. *Pharm. J. Trans.* xiii, 80.
- On the determination of phosphoric acid: by *E. T. Bennett*. *Chem. Gaz.* 1853, 17.
- Picric.—Action of sulphuretted hydrogen on picric acid: by *A. Girard*. *Compt. rend.* xxxvi, 421.
- Means of detecting picric acid in beer: by *J. L. Lassaigne*. *Pharm. J. Trans.* xiii, 139.
- On the use of picric acid for distinguishing vegetable and animal fibres in stuffs: by *J. J. Pohl*. *Sitzungsber. d. Akad. d. Wiss. zu Wien*, ix, 387; *Pharm. J. Trans.* xiii, 183; *Chem. Gaz.* 1853, 320.

- Acid, Propionic.—Note on the preparation of propionic and caproic acids: by *A. W. Williamson*. *Phil. Mag.* [4] vi, 204.
- Pyrogallic.—Pyrogallic acid in wood-vinegar. *Ann. Ch. Pharm.* lxxxvii, 256.
- Pyromeconic.—On some salts and products of decomposition of pyromeconic acid: by *J. Brown*. *Phil. Mag.* [4] iv, 16; *abstr. Chem. Soc. Qu. J.* vi, 78.
- Pyromucic.—Preparation of pyromucic acid: by *A. E. Arppe*. *Ann. Ch. Pharm.* lxxxvii, 237.
- Racemic.—New facts relating to the history of racemic acid: by *M. Kestner*. *Compt. rend.* xxxvi, 17.—Remarks on the preceding: by *M. Biot*. *Ibid.* 18.
- Notice respecting the origin of racemic acid: by *M. Pasteur*. *Compt. rend.* xxxvi, 19.
- On racemic acid. *Pharm. J. Trans.* xiii, 110.
- Salicylic.—On the sensibility of the reactions of salicylous and salicylic acids on sesquioxide of iron: by *A. Dollfus*. *J. Pharm.* [3] xxiv, 202.
- Salicylous.—On the formation of salicylous acid in the flowers of *Spiræa ulmaria*: by *L. A. Buchner*. *J. Pharm.* [3] xxiii, 321; *Pharm. J. Trans.* xiii, 87.
- Sebacic.—On sebacic acid: by *M. Carlet*. *Compt. rend.* xxxvii, 128; *J. Pharm.* [3] xxiii, 176.
- On an apparently new mode of formation of sebacic acid, and on the constitution of the acids $C_n H_{n-2} O_8$: by *R. Wagner*. *Chem. Gaz.* 1853, 155.
- Stearic.—On the solid compound obtained by distilling stearic acid with lime: by *T. H. Rowney*. *Chem. Soc. Qu. J.* vi, 97.
- Sulphuric.—Researches on the congelation and ebullition of the hydrates of sulphuric acid: by *C. Marignac*. *Ann. Ch. Phys.* [3] xxxix, 184.
- On the analysis of oils by means of sulphuric acid: by *M. Maumené*.
- On the manufacture of sulphuric acid: by *M. Gautier*. *Compt. rend.* xxxvii, 177.
- Improvements in the manufacture of sulphuric acid (Bell's Patent). *Pharm. J. Trans.* xii, 451.
- Tannic.—On the preparation of the tannic acid: by *B. Sandrock*. *Chem. Gaz.* 1853, 199; *Pharm. J. Trans.* xii, 597.
- Tartaric.—Transformation of the two tartaric acids into racemic acid. Discovery of inactive tartaric acid. New method of separating racemic acid into dextro- and lævo-tartaric acid: by *L. Pasteur*. *Compt. rend.* xxxvii, 162; *Chem. Soc. Qu. J.* vi, 77.
- Uric.—Preparation of uric acid: by *A. E. Arppe*. *Ann. Ch. Pharm.* lxxxvii, 237.
- Valerianic.—On anhydrous valerianic acid: by *L. Chiozza*. *Chem. Gaz.* 1853, 52.
- On the cacodyl of valerianic acid: by *W. Gibbs*. *Ann. Ch. Pharm.* lxxxvi, 222; *Chem. Gaz.* 1853, 125.
- Acids.—On the acids contained in fungi: by *P. Bolley*. *Ann. Ch. Pharm.* lxxxvi, 44; *Chem. Gaz.* 1853, 291.

- Acids.—On the compounds of glycerine with acids: by *M. Berthelot*. *Compt. rend.* xxxvi, 27; *Chem. Gaz.* 1853, 121.
- On the acids of rape-oil: by *G. Stüdeker*. *Ann. Ch. Pharm.* lxxxvii, 133.
- On the acid formed when potash acts on oil of bitter almonds: by *Prof. Gregory*. *Proc. Roy. Soc. of Edinb.* 1852-53, 195.
- Action exerted by acids and by alkaline and earthy chlorides on oil of turpentine, sugar, alcohol, and wood-spirit: by *M. Berthelot*. *Ann. Ch. Phys.* [3] xxxviii, 38.
- Acids Anhydrous.—Researches on the anhydrous organic acids: by *C. Gerhardt*. *Ann. Ch. Phys.* [3] xxxvii, 285; *Ann. Ch. Pharm.* lxxxvii, 57, 129.
- On anhydrous organic acids: by *L. Chiozza*. *Ann. Ch. Pharm.* lxxxiv, 106; lxxxv, 229; lxxxvi, 259; *Compt. rend.* xxxvi, 632; *Ann. Ch. Phys.* [3] xxxix, 196; *Chem. Soc. Qu. J.* vi, 184.
- Additional researches on the anhydrous acids: by *C. Gerhardt* and *L. Chiozza*. *Compt. rend.* xxxvi, 1050; *Ann. Ch. Pharm.* lxxxvii, 290
- Report on a memoir by *M. Gerhardt*, entitled: "Researches on the anhydrous organic acids": by *M. Dumas*. *Compt. rend.* xxxvi, 505; *J. Pharm.* [3], xxiv, 81; *Pharm. J. Trans.* xiii, 71.
- On Gerhardt's discovery of anhydrous organic acids: by *A. W. Williamson*. *Chem. Gaz.* 1853, 137.
- Fatty.—Researches on the fatty acids: by *W. Heintz*. *Chem. Gaz.* 1853, 41.
- On the use of the fatty acids as a source of light: by *J. Cambacères*. *Chem. Gaz.* 1853, 175.
- Isomeric.—Facts relating to the history of the isomeric acids: by *J. Gottlieb*. *Ann. Ch. Pharm.* lxxxiii, 227; *Ann. Ch. Phys.* [3] xxxviii, 363. Farther: *Ann. Ch. Pharm.* lxxxv, 17.
- Organic.—On certain organic acids: by *L. Chiozza*. *Compt. rend.* xxxvi, 701.
- Æsculin.—Addendum to the memoir on æsculin: by *Fr. Rochleder*. *Ann. Ch. Pharm.* lxxxvii, 200.
- On æsculin: by *F. Rochleder* and *R. Schwartz*. *Ann. Ch. Phys.* [3] xxxviii, 373; *J. Pharm.* [3] xxiv, 292.
- Affinity.—Researches on chemical affinity: by *R. Bunsen*. *Ann. Ch. Pharm.* lxxxv, 137; *Ann. Ch. Phys.* [3] xxxviii, 344; *Chem. Soc. Qu. J.* vi, 82.
- On chemical affinity: by *H. Debus*. *Ann. Ch. Pharm.* lxxxv, 103; lxxxvi, 156; lxxxvii, 238.
- Air.—Researches on the composition of atmospheric air: by *F. Regnault*. *Ann. Ch. Phys.* xxxvi, 385.
- On the composition of the air contained in vegetable mould: by *Boussingault* and *Lévy*. *Ann. Ch. Phys.* [3] xxxvii, 5.
- Specific heat of air: by *W. J. M. Rankine*. *Phil. Mag.* [4] v, 437.
- Air-pump.—Improvements in the air-pump: by *M. Breton*. *Compt. rend.* xxxvi, 587.—Report thereupon: by *M. Regnier*. *Ibid.* 1068.
- Albumin.—On albumin and casein: by *N. Lieberkühn*. *Pogg. Ann.* lxxxvi, 117, 298; *abstr. J. Pharm.* [3] xxiii, 398.
- On the presence of albumin in milk in the normal state: by *M. Quévenne*. *J. Pharm.* [3] xxiv, 94.

- Albumin.—New observations on albuminoid substances: by *M. Panum*.
Ann. Ch. Phys. [3] xxxvii, 237; J. Pharm. [3] xxiii, 238.
- Researches on albuminoid substances: by *C. Leronte* and *A. de Goumuens*.
Compt. rend. xxxvi, 837; J. Pharm. [3] xxiv, 17.
- Alcohol.—New process for recognizing the presence of alcohol in essential oils: by *M. Oberdörfer*. J. Pharm. [3] xxiv, 73.
- Action exerted by acids and by alkaline and earthy chlorides on alcohol: by *M. Berthelot*. Ann. Ch. Phys. [3] xxxviii, 38.
- Alcohols.—On the acidification of alcohols by oxygen gas or atmospheric air: by *R. Railton*. Chem. Soc. Qu. J, vi, 205.
- On the atomic weight and constitution of the alcohols: by *F. Wrightson*. Phil. Mag. [4] vi, 88.
- On butylic alcohol: by *A. Wurtz*. Ann. Ch. Pharm. lxxxv, 197.
- On caproic alcohol: by *M. Faget*. Compt. rend. xxxvii, 730.
- On caprylic alcohol: by *Wladimir Moschnin*. Ann. Ch. Pharm. lxxxvii, 111.
- On propionic alcohol: by *G. Chancel*. Compt. rend. xxxvii, 410; Chem. Soc. Qu. J. vi, 287.
- Aldehyde.—On the occurrence of aldehyde among the products of the distillation of sugar: by *C. Völckel*. Ann. Ch. Pharm. lxxxvii, 303.
- On aldehyde-ammonia. Ann. Ch. Pharm. lxxxvi, 375.
- Aldehydes.—On a new mode of formation of the aldehydes: by *L. Chiozza*. Ann. Ch. Pharm. lxxxv, 232.
- Alkali.—Improvements in the manufacture of alkali (Greenshield's Patent). Chem. Gaz. 1853, 438.
- Alkalies.—New and ready method of determining the alkalies in minerals: by *J. L. Smith*. Sill. Am. J. [2] xv, 234; xvi, 53; Chem. Gaz, 1853, 252, 333.
- Researches on the cinchona alkaloids: by *L. Pasteur*. Compt. rend. xxxvii, 110; J. Pharm. [3] xxiii, 16; Chem. Soc. Qu. J. vi, 273.
- On the tests for the cinchona alkaloids: by *F. L. Winckler*. Pharm. J. Trans. xii, 422.
- Researches on a new alkali (piperidine), derived from piperine: by *A. Cahours*. Ann. Ch. Phys. [3] xxxviii, 38.
- Production of the ethylic and methylic alkaloids by means of chloride of ammonium: by *M. Berthelot*. Ann. Ch. Phys. [3] xxxviii, 38.
- On some new basic products obtained by the decomposition of the vegetable alkaloids: by *H. How*. Chem. Soc. Qu. J. vi, 125.
- Action of alkalis on sugar. Pharm. J. Trans. xii, 348, 393.
- General process for the detection of the alkaloids in cases of poisoning: by *G. Stas*. Pharm. J. Trans. xiii, 132.
- Alloxan.—On a spontaneous metamorphosis of alloxan: by *Prof. Gregory*. Proc. Roy. Soc. Edinb. 1852-53, 197; Ann. Ch. Pharm. lxxxviii, 126.
- Alloys.—On alloys considered with reference to their chemical constitution: by *A. Levol*. Ann. Ch. Phys. [3] xxxix, 163.
- On the position of alloys and amalgams in the thermo-electric series: by *W. Rollmann*. Pogg. Ann. lxxxix, 90.
- On the analysis of alloys of copper and zinc: by *H. Spirgatis*. J. pr. Chem. vii, 184; Chem. Gaz. 1853, 260.
- Note on a new alloy of silver: by *G. Barruel*. Chem. Gaz. 1853, 15.

- Alloys.—Improvements in depositing alloys of metals (Marris and Johnston's Patent). *Pharm. J. Trans.* xiii, 233.
- Alum.—Note on cubic alum: by *H. Loewel*. *Compt. rend.* xxxvi, 595.
- Alumina.—On the presence of alumina in Bog-head coal, and on the use of the ashes of the latter in the manufacture of alum: by *T. J. Herapath*. *Chem. Gaz.* 1853, 169.
- On the acetates and other compounds of alumina: by *Walter Crum*. *Chem. Soc. Qu. J.* vi, 217.
- New reagent for precipitating alumina from its acid solutions: by *M. Tissier*. *Compt. rend.* xxxvii, 245.
- On the separation of alumina from oxide of chromium: by *Dexter*. *Pogg. Ann.* lxxxix, 142.
- Amalgamation.—On the reactions on which the American amalgamation process depends, and on the extraction of silver by means of amalgamation: by *Dr. Karsten*. *Chem. Gaz.* 1853, 141.
- Amber.—On cavities in amber containing gases and liquids: by *D. Brewster*, *Phil. Mag.* [4] v, 233.
- Amides.—Researches on the amides: by *C. Gerhardt* and *L. Chiozza*. *Ann. Ch. Pharm.* lxxxvii, 296; *Chem. Soc. Qu. J.* vi, 193.
- Note on the theory of the amides: by *A. Wurtz*. *Compt. rend.* xxxvii, 246, 357.
- Note on the theory of the amides: by *C. Gerhardt*. *Compt. rend.* xxxvii, 281.
- Ammonia.—Note on the use of graduated solutions for determining the quantity of ammonia in waters: by *M. Bineau*. *Compt. rend.* xxxvi, 1039.
- Method of getting rid of sal-ammoniac in analysis: by *J. L. Smith*. *Sill. Am. J.* [2] xv, 94.
- New researches on the ammonia in the atmosphere: by *J. Pierre*. *Compt. rend.* xxxvi, 694.
- On the quantity of ammonia in rain-water collected at a distance from towns: by *M. Boussingault*. *Compt. rend.* xxxvii, 207.
- On the action of ammoniacal bases upon oil of mustard: by *F. Hinterberger*. *Chem. Gaz.* 1853, 71.
- On the combustion of ammonia, &c., by the green oxide of chromium: by *J. E. Ashby*. *Phil. Mag.* [4] vi, 97.
- On the reaction of ammonia on certain metallic arsenites: by *A. Girard*. *Compt. rend.* xxxvi, 793.
- Action of ammonia on sulphamylate of lime: by *M. Berthelot*. *Compt. rend.* xxxvi, 1098.
- On the supposed conversion of ammonia into nitric acid in the animal body: by *C. Jaffé*. *J. pr. Chem.* lix, 238; *J. Pharm.* [3] xxiv, 373; *Pharm. J. Trans.* xiii, 232.
- On the determination of the ammonia contained in waters: by *M. Boussingault*. *Compt. rend.* xxxvi, 814; *Chem. Gaz.* 1853, 319.
- Manufacture of ammonia and ammoniacal salts. *Pharm. J. Trans.* xiii, 29, 63, 112.
- On the fabrication of sal-ammoniac: by *MM. Möhrlin* and *Stoll*. *Bull. de la Soc. industr. de Mulhouse*, xxiv, 375.

- Ammonia.—On the estimation of ammonia in waters: by *M. Boussingault*. Ann. Ch. Phys. [3] xxxix, 257.
- Amygdalin.—On the presence of amygdalin in various plants. Pharm. J. Trans. xii, 450.
- Amyl.—On the preparation of carbonate of amyl: by *J. A. Bruce*. Ann. Ch. Pharm. lxxxv, 16.
- On the action of ammonia on sulphamylate of lime: by *M. Berthelot*. Ann. Ch. Pharm. lxxxvii, 372.
- Anæsthetic Agents.—Considerations on anæsthetic agents: by *M. Jobert*. Compt. rend. xxxvi, 1031.
- Analysis.—New general method of chemical analysis: by *H. Sainte-Claire Deville*. Ann. Ch. Phys. [3] xxxviii, 5.
- On a method of volumetric analysis of very general application: by *R. Buusen*. Ann. Ch. Pharm. lxxxvi, 265.
- A method of getting rid of sal-ammoniac in analysis: by *J. L. Smith*. Sill. Am. J. [2] xv, 94; Chem. Gaz. 1853, 115.
- Note on the use of chlorine in analysis: by *MM. Rivot, Beudant, and Daguin*. Compt. rend. xxxvii, 126; J. Pharm. [3] xxiii, 169.
- On the use of cyanide of potassium in analytical chemistry: by *H. Rose*. Pogg. Ann. xc, 193.
- Analytical notes: by *A. B. Northcote* and *A. H. Church*. Chem. Soc. Qu. J. vi, 53.
1. Action of caustic potash on the phosphates.
2. On the behaviour of some oxides with caustic potash in the presence of oxide of chromium.
- Contributions to analytical chemistry: by *W. Gibbs*. Ann. Ch. Pharm. lxxxvi, 52.
- Separation of manganese from potash and soda; from baryta, strontia, lime, magnesia and alumina; from zinc and nickel.
- On volumetrical analysis. Pharm. J. Trans. xiii, 284.
- Aniline.—Test for aniline. Ann. Ch. Pharm. lxxxvii, 376.
- Test for aniline: by *F. Beissenhirtz*. Chem. Gaz. 1853, 434.
- Ant.—Chemical investigation of the Mexican honey-ant: by *C. M. Wetherill*. Chem. Gaz. 1853, 72.
- Antimony.—On the isomeric compounds of sulphur and antimony: by *H. Rose*. Ber. d. Akad. d. Wiss. zu Berlin, 1853, 242; Chem. Gaz. 1853, 290.
- On the isomeric modifications of sulphide of antimony: by *H. Rose*. Pogg. Ann. lxxxix, 122.
- On the compounds of sulphide of antimony with antimonic oxide: by *H. Rose*. Pogg. Ann. lxxxix, 316.
- Action of antimony upon certain classes of salts: by *J. W. Slater*. Chem. Gaz. 1853, 329.
- On the fluorine-salts of antimony: by *F. A. Flückiger*. Chem. Gaz. 1853, 1.
- On the sulphide of antimony: by *F. Wackenroder*. Arch. Pharm. [2] lxxi, 207; J. Pharm. [3] xxiii, 156.
- Note on the sulphantimoniate of copper and zinc: by *Prof Ettling*. Chem. Soc. Qu. J. vi, 140.

- Antimony.**—On the preparation of lakes by means of chloride of antimony Schweiz. Gewerbeblatt, xi, 217; Chem. Gaz. 1853, 275.
- Antiquities.**—Analyses of several artificial products of high antiquity: by *M. Girardin*. J. Pharm. [3] xxiii, 165, 252, 324.
- Aqua-regia.**—Use of aqua-regia in testing for poisons: by *Gaultier de Claubry*. J. Pharm. [3] xxiii, 27, 209.—Remarks on the same: by *Malaguti* and *Sarzeaud*. Ibid. 296.
- Arbutine.**—On arbutine: by *M. Kawalier*. Ann. Ch. Phys. [3] xxxviii, 375.
— On arbutine: by *Rochleder* and *Schwartz*. J. Pharm. [3] xxiv, 293.
- Arctostaphylos.**—Examination of the leaves of *Arctostaphylos Ura Ursi*: by *A. Kawalier*. Chem. Gaz. 1853, 61.
- Arnica.**—Adulteration of arnica leaves. Pharm. J. Trans. xii, 400.
- Arsenic.**—On arsenious acid, its salts, and the arsenio-sulphides: by *O. B. Kühn*. Arch. Pharm. cxix, 267, and cxxi, 1; Chem. Gaz. 1853, 364.
— On vitreous arsenious acid: by *C. Brame*. Compt. rend. xxxvii, 90.
— Action of arsenic upon certain classes of salts: by *J. W. Draper*. Chem. Gaz. 1853, 329.
— On the use of molybdate of ammonia as a test for arsenic in medico-legal investigations: by *H. Struve*. J. pr. Chem. lviii, 193; J. Pharm. [3] xxiv, 374; Pharm. J. Trans. xiii, 182.
— On the toxicological relations of arsenious and arsenic acids: by *M. Schroff*. J. Pharm. [3] xxiv, 294.
— On the reduction of arsenic and antimony by means of cyanide of potassium: by *H. Rose*. Bericht d. Akad. d. Wiss. zu Berlin, 1853, 441; Chem. Gaz. 1853, 400.
— On the use of aqua-regia in searching for arsenic localized in the viscera: by *Malaguti* and *Sarzeaud*. J. Pharm. [3] xxiii, 27.
— Comparative experiments on the use of hydrate of magnesia and hydrated sesquioxide of iron as antidotes for arsenic: by *K. D. Schroff*, N. Repert. Pharm. i, 447; J. Pharm. [3] xxiii, 230; Pharm. J. Trans. xiii, 38.
— Insolubility of native realgar (As_2S_3) in carbonate of ammonia: by *C. G. Williams*. Chem. Gaz. 1853, 252.
- Arsenites.**—On the action of ammonia on certain metallic arsenites: by *A. Girard*. Compt. rend. xxxvi, 793.
- Ashes.**—Analysis of the ashes of *Erica carnea* and *Calluna vulgaris* Salisb. and of the soils on which they grow: by *C. F. Röthe*. Ann. Ch. Pharm. lxxxvii, 118.
— Analysis of the ashes of vetch-seed from Neufchatel: by *J. Cohen*. Ann. Ch. Pharm. lxxxiv, 288.
- Asphalt.**—On asphalt from Canton Neuenburg: by *C. Fölckel*. Ann. Ch. Pharm. lxxxvii, 139.
- Aspirator.**—New gasometer, serving as a pneumatic trough and as an aspirator: by *M. Tiffreau*. Compt. rend. xxxvii, 51.
— On a new aspirator: by *T. Andrews*. Pogg. Ann. lxxxviii, 603; Ann. Ch. Pharm. lxxxv, 263.
- Assaying.**—Abstract of the assays performed at the École des Mines: by *MM. Rivot, Beudant, Dognin, and Bouquet*. Ann. Min. [5] iii, 521.

- Atomic Weights.—Addition to a memoir entitled: "Researches on the relations between the atomic weights and specific heat of elementary bodies": by *M. Granier*. *Compt. rend.* xxxvii, 130.
- On the relations between the atomic weights of analogous elements: by *J. H. Gladstone*. *Phil. Mag.* [4] v, 313.
- Azobenzide.—Note upon azobenzide and seminaphthalidine: by *N. Zinin*. *Bull. de St. Petersb. Phys. Math. Cl.* x, 348; *Ann. Ch. Pharm.* lxxxv, 328; *Chem. Gaz.* 1853, 32.

B.

- Balance.—On an improved assay balance: by *G. H. Makins*. *Chem. Soc. Qu. J.* vi, 36.
- On a new balance for taking the tare of vessels. *J. Pharm.* [3] xxiv, 354.
- Balsams.—Adulteration of Peru and Tolu balsams; by *G. Ulex*. *Pharm. J. Trans.* xii, 549.
- Bark.—On a bark called *Heetoo*, used in Abyssinia, with some remarks on the *Korarima* and on *Koussoo*: by *J. Vaughan*. *Pharm. J. Trans.* xii, 587.
- Barmin.—On the equivalent weights of platinum and barmium: by *T. Andrews*. *Ann. Ch. Pharm.* lxxxv, 255.
- Baryta.—Manufacture of caustic baryta from the carbonate: by *MM. Leplay* and *Dubrunfaut*. *Chem. Gaz.* 1853, 388.
- Bases.—Contributions to the history of the volatile bases; by *A. v. Planta* and *A. Kekulé*. *Ann. Ch. Pharm.* lxxxvii, 1.
- Bee.—Chemical examination of the food of the queen-bee: by *C. M. Wetherill*. *Chem. Gaz.* 1853, 91.
- Beer.—Means of detecting picric acid in beer: by *J. L. Lassaigne*. *Pharm. J. Trans.* xiii, 139.
- Bees.—Remedy for the stings of bees. *Chem. Gaz.* 1853, 36.
- Beet.—Note on the chemical composition of the beet-root, cultivated in the alumino-siliceous soils of the Loire-Inférieure: by *M. Bobierre*. *Compt. rend.* xxxvi, 31; *Chem. Gaz.* 1853, 154.
- Benzoates.—On benzoate of potash: by *W. Gregory*. *Ann. Ch. Pharm.* lxxxvii, 125.
- Bismuth.—Researches on bisnuth: by *R. Schneider*. *Pogg. Ann.* lxxxviii, 46; xc, 166.
- On *magistery of bismuth*, and certain other compounds of nitric acid with oxide of bismuth. *J. Pharm.* [3] xxiii, 319.
- Bitter Principles.—On certain bitter principles: by *Fr. Rochleder* and *R. Schwartz*. *Ann. Ch. Pharm.* lxxxvii, 186; *J. Pharm.* [3] xxiii, 474.
- Blast Furnaces.—On the arrangement of the materials in the blast furnace and the application of the waste gases: by *S. H. Blackmore*. *J. Fr. Inst.* [3] xxv, 188, 243.
- Bleaching.—On the mode of testing the strength of bleaching liquors: by *F. Lieshing*. *Chem. Gaz.* 1853, 139.
- Blood.—On the crystallizable matter of the blood: by *M. Lehmann*. *J. pr. Chem.* lviii, 95; *J. Pharm.* [3] xxiv, 368.

- Blood.**—On a new method of coagulating blood in the arteries, and its application to the cure of aneurisms: by *M. Prevaz*. *Compt. rend.* xxxvi, 88.
- Further observations of the crystallizable method of the blood: by *C. G. Lehmann*. *Ber. d. Gesellsch. d. Wiss. zu Leipzig. Math.-Phys. Classe*, 1852, 78; *Chem. Gaz.* 1853, 447.
- Boiler.**—Note on a new steam-boiler by *M. Boutigny*. *J. Pharm.* [3] xxiii, 53.
- Bone.**—Improvements in producing ornamental surfaces in metal, ivory, or bone (Skinner's Patent). *Chem. Gaz.* 1853, 59.
- Bones.**—On the alteration of bones in the soil: by *Kindler*. *Pogg. Ann.* lxxxvii, 611.
- Borates.**—Examination of a natural product imported from America, and partly consisting of the borates of soda and lime: by *L. R. Lecanu*. *J. Pharm.* [3] xxiv, 22; *Pharm. J. Trans.* xiii, 184; *Compt. rend.* xxxvi, 580.
- Brain.**—Comparative investigation of the quantities of water and fat in the brain: by *J. Hauff* and *R. Walther*. *Ann. Ch. Pharm.* lxxxv, 42.
- On the brain: by *E. v. Bibra*. *Ann. Ch. Pharm.* lxxxv, 201.
- On the brain of the new-born infant: by *J. Schlossberger*. *Ann. Ch. Pharm.* lxxxvi, 119.
- Bran.**—On the chemical composition of bran: by *M. Poggiale*. *Compt. rend.* xxxvii, 171; *J. Pharm.* [3] xxiii, 198.
- On the influence of the glucosic ferments contained in bran on the process of panification: by *M. Mouries*. *Compt. rend.* xxxvii, 427.
- Report by *M. Chevreul* on a memoir by *M. Mouries* entitled: "On the proximate principles of wheat-bran, of their action in panification, and in the nutrition of animals." *Compt. rend.* xxxvii, 775.
- Brandy.**—Means of detecting and separating copper from brandy. *Pharm. J. Trans.* xiii, 294.
- Brass.**—Fire-proof bronze-colour for copper and brass: by *M. Dienst*. *Chem. Gaz.* 1853, 119.
- Bread.**—Examination of the bread supplied to the troops of the various European powers, and of the chemical composition of bran: by *M. Poggiale*. *Compt. rend.* xxxvii, 171; *J. Pharm.* [3] xxiii, 198.
- Experiments to determine the cause of the difference between new and stale bread: by *M. Boussingault*. *Ann. Ch. Phys.* [3] xxxvi, 490; *Chem. Gaz.* 1853, 47.
- Bromine.**—On a process for determining the equivalents of certain fluid hydrocarbons by means of bromine: by *C. G. Williams*. *Chem. Gaz.* 1853, 365.
- Bronze.**—On the alteration of bronzes used for the sheathing of the ships. *Compt. rend.* xxxvii, 131.
- Burette.**—On a new burette: by *R. Kersting*. *Ann. Ch. Pharm.* lxxxvii, 33.
- Butter.**—On butter: by *W. Heintz*. *Pogg. Ann.* xc, 137.
- On the composition of butter: by *W. Heintz*. *Ber. d. Akad. d. Wiss. zu Berlin*, 1853, 303; *Chem. Gaz.* 1853, 441.
- Butyl.**—On butylic alcohol: by *A. Wurtz*. *Ann. Ch. Pharm.* lxxxv, 197.

C.

- Cacodyl.—On the cacodyl of valerianic acid: by *W. Gibbs*. Chem. Gaz. 1853, 125.
- Cadmium.—On an artificial production of Greenockite, and of some other compounds of cadmium: by *E. Schüler*. Ann. Ch. Pharm. lxxxvii, 34.
- Calico-printing.—On the applicability of molybdic acid and the molybdates in dyeing and calico-printing: by *W. H. Kurrer*. Chem. Gaz. 1853, 435.
- Analysis of a new alloy for the plates for calico-printing. J. pr. Chem. 192; J. Fr. Inst. [3] xxv, 68.
- Calluna.—Analysis of the ashes of *Erica carnea* and *Calluna vulgaris* Salisb., and of the soils on which they grow: by *C. F. Röthe*. Ann. Ch. Pharm. lxxxvii, 118.
- Camphor.—On the different kinds of camphor, and on oil of camphor: by *Th. Martius*. J. Pharm. [3] xxiii, 472.
- On lævocamphoric acid and lævocamphor: by *J. Chautard*. Compt. rend. xxxvii, 166; J. Pharm. [3] xxiii, 168.
- Camphors.—Camphor from oil of sassafras. Ann. Ch. Pharm. lxxxvii, 376.
- Cantharides.—On the nature of the fat of Cantharides: by *Dr. Gössmann*. Ann. Ch. Pharm. lxxxvi, 317.
- Caoutchouc.—On caoutchouc and gutta percha: by *F. C. Calvert*. Pharm. J. Trans. xii, 423.
- Caproyl.—On caproic alcohol: by *M. Faget*. Compt. rend. xxxvii, 730.
- Capryl.—On caprylic alcohol: by *Wladimir Moschnin*. Ann. Ch. Pharm. lxxxvii, 111.
- Carbon.—Observations on carbon and on the difference of temperature of the induced luminous poles: by *M. Despretz*. Compt. rend. xxxvii, 369.
- On the detection of sulphide of carbon: by *A. Vogel*. Ann. Ch. Pharm. lxxxvi, 369.
- Carbonates.—On the occurrence of crystallized carbonate of lanthanum: by *W. O. Blake*. Sill. Am. J. [2] xvi, 228.
- Improvements in the manufacture of carbonates of soda (W. E. Newton's Patent). Chem. Gaz. 1853, 359.
- On the preparation of carbonate of potash: by *C. Weber*. Pharm. J. Trans. xiii, 45.
- On the preparation of carbonate of amyl: by *J. A. Bruce*. Ann. Ch. Pharm. lxxxv, 16.
- Casein.—On albumin and casein: by *N. Lieberkühn*. Pogg. Ann. lxxxvi, 117, 298; *abstr.* J. Pharm. [3] xxiii, 398.
- Catalysis.—Additional observations on catalytic combustion: by *J. E. Ashby*. Phil. Mag. [4] vi, 77.
- Cellulose.—Discovery of a substance in the human body which gives the same reactions as vegetable cellulose: by *M. Virchow*. Compt. rend. xxxvi, 492.
- Cement.—Improved cement for resisting fire (Beale's Patent). Pharm. J. Trans. xiii, 234.

- Charcoal.—New process for determining the commercial value of animal charcoal: by *M. Corenwinder*. *Compt. rend.* xxxvii, 610.
- Memoir on wood-charcoal: by *M. Violette*. *Ann. Ch. Phys.* [3] xxxix, 291.
- Second memoir on charcoal: by *M. Violette*. *J. Pharm.* [3] xxiv, 172.
- Chemical Action.—Researches on the quantities of heat disengaged in chemical and molecular actions (3rd, 4th, and 5th parts—Conclusion): by *P. A. Favre* and *J. T. Silbermann*. *Ann. Ch. Phys.* [3] xxxvii, 406.
- Note on the chemical compounds produced by *slow action* at the contact of solids and liquids: by *M. Becquerel*. *Compt. rend.* xxxvi, 209.
- Considerations on the theory of chemical changes and on the law of equivalent volumes: by *T. S. Hunt*. *Sill. Am. J.* [2] xv, 226.
- Chemical Changes.—Considerations on the theory of chemical changes and on equivalent volumes: by *T. S. Hunt*. *Phil. Mag.* [4] v, 326.
- Chemical Combination.—On the heat of chemical combination: by *T. Woods*. *Phil. Mag.* [4] v, 10.
- Chemical Composition.—New researches on the relations which may exist between crystalline form, chemical composition, and rotatory power: by *L. Pasteur*. *Ann. Ch. Phys.* [3] xxxviii, 437.—Report thereupon: by *H. de Senarmont*. *Compt. rend.* xxxvi, 757.
- Chemical Forces.—On the economical production of mechanical effect from chemical forces: by *J. P. Joule*. *Phil. Mag.* [4] v, 1.
- On the mechanical effect of heat and chemical forces: by *W. J. Rankine*. *Phil. Mag.* [4] v, 6.
- Chicory.—On the means of detecting chicory in coffee: by *J. L. Lassaigne*. *Pharm. J. Trans.* xiii, 224.
- Chlorides.—Action exerted by acids and by alkaline and earthy chlorides on oil of turpentine, sugar, alcohol, and wood-spirit: by *M. Berthelot*. *Ann. Ch. Phys.* [3] xxxviii, 38.
- Compounds of the sulphides of ethyl and methyl with certain metallic chlorides: by *A. Low*. *J. Pharm.* [3] xxxv, 251; *Ann. Ch. Pharm.* lxxxvii, 369; *Chem. Gaz.* 1853, 361; *Compt. rend.* xxxvi, 1095.
- On the analysis of mineral waters containing chloride of magnesium: by *M. Tillmanns*. *J. Pharm.* [3] xxiii, 234.
- Chlorine.—On a new method of determining the amount of available chlorine contained in hypochlorites of lime, potash, or soda: by *A. P. Price*. *Chem. Gaz.* 1853, 419.
- Note on the use of chlorine in analyses: by *MM. Rivot, Beudant, and Daquin*. *Compt. rend.* xxxvii, 126; *J. Pharm.* [3] xxiii, 169.
- Improvements in the manufacture of chlorine (Pattinson's Patent). *Pharm. J. Trans.* xii, 354.
- Chloroform.—On the nature of the oily substance existing in commercial chloroform: by *H. Pemberton*. *Pharm. J. Trans.* xii, 599.
- Chromium.—On the behaviour of certain oxides with caustic potash in the presence of oxide of chromium: by *A. B. Northcote* and *A. H. Church*. *Chem. Soc. Qu. J.* vi, 54.
- On minerals accompanying chromic iron: by *T. H. Garret*. *Sill. Am. J.* [2] xv, 332.
- On the separation of alumina from oxide of chromium: by *Dexter*. *Pogg.* *Ann.* lxxxix, 142.

- Chromium.—On the toxicology of bichromate of potash : by *M. Jaillard*. J. Pharm. [5] xxiv, 39.
- On the combustion of ammonia, &c., by the green oxide of chromium : by *J. E. Ashby*. Phil. Mag. [4] vi, 97.
- On the preparation of chrome-yellow : by *MM. Riot and Delisse*. Pharm. J. Trans. xiii, 139.
- Cheap method of preparing chrome-red : by *Prof. Runge*. Pharm. J. Trans. xiii, 90.
- Cinchona.—Manufacture of chromate and bichromate of potash from chromic iron or chrome ore (*J. Booth's Patent*). Chem. Gaz. 1853, 478.
- Researches on the cinchona-alkaloids : by *L. Pasteur*. Compt. rend. xxxvii, 110; J. Pharm. [3] xxiii, 161; Chem. Soc. Qu. J. vi, 273.
- Cinchonine.—Action of carbonic acid on quinine and cinchonine : by *M. Langlois*. Compt. rend. xxxvii, 727.
- Citrates.—On the crystalline forms of certain citrates : by *J. C. Heusser*. Pogg. Ann. lxxxviii, 121.
- On the adulteration of commercial citrate of iron and quinine : by *C. G. Williams*. Chem. Gaz. 1853, 269.
- Clay.—Analysis of light-grey clay from Wiesloch : by *J. Moser*. Ann. Ch. Pharm. lxxxv, 99.
- On plastic clay (*terre molle*) : by *M. Barreswil*. J. Pharm. [3] xxii, 444.
- Coal.—Description of a brown coal deposit in Brandon, Vermont, U.S. : by *E. Hitchcock*. Sill. Am. J. [2] xv, 95.
- On the presence of alumina in Bog-head coal, and on the use of the ashes of the latter in the manufacture of alum : by *T. J. Herapath*. Chem. Gaz. 1853, 169.
- Improved method of treating coal and bituminous substances, and improvements in the treatment of their volatile products (*W. Brown's Patent*). Chem. Gaz. 1853, 476.
- Cobalt.—On an allotropic modification of cobalt : by *F. A. Genth*. Chem. Gaz. 1853, 91.
- On the new compounds for cobalt described by Frémy and others : by *Prof. Gregory*. Proc. Roy. Soc. Edinb. 1852-53, 193; Ann. Ch. Pharm. lxxxvii, 125.
- Researches on cobalt : by *E. Frémy*. Ann. Ch. Phys. xxxv, 257; Chem. Gaz. 1853, 201.
- On a new saline compound of cobalt : by *E. St. Evre*. Ann. Ch. Phys. [3] xxxviii, 177.
- Cobalt-yellow. Pogg. Ann. lxxxviii, 496.
- On the compounds of boracic acid and water with protoxide of cobalt : by *H. Rose*. Pogg. Ann. lxxxviii, 299.
- On the passive state of nickel and cobalt : by *J. Nicklés*. Compt. rend. xxxvii, 284.
- Separation of nickel from cobalt. Ann. Ch. Pharm. lxxxvii, 128.
- On the presence of nickel and cobalt in ferruginous waters, and on a process for isolating them : by *O. Henry*. J. Pharm. [3] xxiv, 305.
- Coca.—On coca leaves : by *H. Wackenroder*. Pharm. J. Trans. xiii, 224.
- On the properties and composition of the coca-leaf : by *Prof. Johnston*. Chem. Gaz. 1853, 438.

- Codeine.—On the rotatory power of codeine : by *Bouchardat* and *F. Boudet*. J. Pharm. [3] xxiii, 288.
- Coffee.—On coffee as a beverage, considered in a chemico-physiological point of view : by *J. Lehmann*. Ann. Ch. Pharm. lxxxvii, 205, 275.
- Examination of the chicoried coffees found in commerce : by *A. Marquis*. J. Pharm. [3] xxiv, 210.
- Cohesion.—Mémorial on cohesion : by *M. Seguin*. Compt. rend. xxxvii, 698.
- Coke.—On the purification of iron and coke from sulphur. J. Fr. Inst. [3] xxv, 47.
- Colouring Matter.—On the constitution of the colouring matters of madder : by *E. Schunck*. Phil. Mag. [4] vi, 187.
- On a new yellow colouring matter in the root-bark of *Rhamnus frangula* : by *L. A. Büchner*. Ann. Ch. Pharm. lxxxvii, 218 ; J. Pharm. [3] xxiv, 50.
- Wurrus, a dye from *Rottlera tinctoria* : by *D. Hanbury*. Pharm. J. Trans. xii, 589.
- Fire-proof bronze-colour for copper and brass : by *M. Dieust*. Chem. Gaz. 1853, 119.
- Report on English colours : by *E. Ehrmann*. Bull. Soc. Ind. de Mulhouse. No. 115, p. 400.
- Copper.—On copper smelting : by *J. Napier*. Phil. Mag. [4] v, 30, 175, 345, 486.
- On the compounds of boracic acid and water with oxide of copper : by *H. Rose*. Pogg. Ann. lxxxvii, 587.
- On the chemical compounds of copper and tin, and on mixtures of these metals constituting non-chemical alloys : by *M. Rieffel*. Compt. rend. xxxvii, 450.
- On the analysis of alloys of copper and zinc : by *H. Spirgatis*. J. pr. Chem. lvii, 84 ; Chem. Gaz. 1853, 260.
- Note on sulphantimoniate of copper and zinc : by *Prof. Ettling*. Chem. Soc. Qu. J. vi, 140.
- On certain compounds of copper with cyanogen : by *A. Dufau*. Compt. rend. xxxvi, 1099.
- On several new sulphites of cuprous oxide : by *L. Péan de St. Gilles*. J. Pharm. [3] xxiii, 45 ; Compt. rend. xxxvi, 1086—Remarks thereupon : by *M. Chevreul*. Ibid. 1089.
- On grey copper (probably a new mineral) from Cabarras County, N. C. : by *F. A. Genth*. Sill. Am. J. [2] xvi, 83.
- Chloride of zinc as a solvent for copper. Pharm. J. Trans. xiii, 233.
- On the determination of copper and nickel in quantitative analysis : by *D. Forbes*. Chem. Gaz. 1853, 276.
- Means of detecting and separating copper in brandy. Pharm. J. Trans. xiii, 294.
- On the volumetric determination of copper : by *F. Liesching*. Chem. Gaz. 1853, 472.
- Corydalis.—On the occurrence of fumaric acid in *Corydalis bulbosa* : by *W. Wicke*. Ann. Ch. Pharm. lxxxvii, 225.
- Cotton.—On the nature of cotton, and on a peculiar fibre of that plant not capable of taking colours : by *W. Crum*. Bull. de la Soc. Industr. de Mulhouse, xxiii, 277.

- Cotton.—On the detection of silk, wool, linen, and cotton fibres in textile fabrics: by *G. C. Wittstein*. Pharm. J. Trans. xiii, 181.
- On the detection of cotton in unbleached linen: by *O. Zimmermann*. Chem. Gaz. 1853, 99.
- Crayons.—Crayons for writing on glass: by *R. Brunnquell*. Chem. Gaz. 1853, 193.
- Creosote —Contributions to the history of creosote and of some of its products of decomposition: by *Gorup-Besanez*. Ann. Ch. Pharm. lxxxvi, 223.
- On the behaviour of creosote with lime at a high temperature: by *C. Völckel*. Ann. Ch. Pharm. lxxxvii, 306.
- On creosote: by *Gorup-Besanez*. Pharm. J. Trans. xiii, 289.
- Crystallography.—New researches on the relations which may exist between crystalline form, chemical composition, and rotatory power: by *L. Pasteur*. Ann. Ch. Phys. [3] xxxviii, 437.—Report on the same: by *H. de Senarmon*. Compt. rend. xxxvi, 751.
- On pseudomorphoses, with consideration of the method of distinguishing certain varieties of them: by *Th. Scheerer*. Pogg. Ann. xc, 315.
- Chemico-crystallographical investigations: by *C. Rammelsberg*. Pogg. Ann. xc, 12.
- Researches on the slow formation of crystals at ordinary temperatures: by *M. Laval*. Compt. rend. xxxvi, 493.
- On the production of crystalline structure in crystallized powders by compression and traction: by *D. Brewster*. Trans. Roy. Soc. Edinb. xx, 335; Phil. Mag. [4] vi, 260; *abstr.* Proc. Roy. Soc. Edinb. 1852-53, 578.
- On circular crystals: by *D. Brewster*. Trans. Roy. Soc. Edinb. xx, 607; *abstr.* Proc. Roy. Soc. Edinb. 1852-53, 188.
- On the optical phenomena and crystallization of tourmaline, titanium, and quartz, within mica, amethyst, and topaz: by *D. Brewster*. Trans. Roy. Soc. Edinb. xx, 547; Proc. Roy. Soc. Edinb. 1852-53, 158; Phil. Mag. [4] vi, 265.
- Report on six memoirs by *M. Brame* on the phenomena which accompany the crystallization of sulphur, phosphorus, and several other bodies: by *M. Dufrénoy*. Compt. rend. xxxvi, 463.
- On some crystals from the sea-coast of Africa: by *J. Pearsall*. Chem. Gaz. 1853, 418.
- Cyanides.—Method of estimating the value of cyanide of mercury: by *F. Liesching*. J. Pharm. [3] xxiv, 279.
- On some double salts of cyanide of mercury: by *G. Kohl* and *A. Swoboda*. Chem. Gaz. 1853, 70.
- On the manufacture of cyanide of potassium by means of atmospheric nitrogen. Pharm. J. Trans. xiii, 291.
- Cyanogen.—Analysis of commercial cyanide of potassium: by *MM. Fordos* and *Gélis*. J. Pharm. [3] xxiii, 48.
- On the use of cyanide of potassium in analytical chemistry: by *H. Rose*. Pogg. Ann. xc, 193.
- On certain compounds of copper with cyanogen: by *A. Dufau*. Compt. rend. xxxvi, 1099.

- Cyanogen.—On the analysis of difficultly decomposable cyanogen-compounds : by *P. Bolley*. Ann. Ch. Pharm. lxxxvii, 254.
- On the estimation of cyanogen by volume-analysis : by *T. J. Herapath*. Chem. Gaz. 1853, 294.
- On the preparation of alkaline cyanide for technical purposes : by *R. Wagner*. Pharm. J. Trans. xiii, 141.
- On the fabrication and valuation of various cyanogen-compounds : by *R. Brunquell*. Pharm. J. Trans. xiii, 226.
- On the decomposition of the cyanic ethers : by *A. Wurtz*. Compt. rend. xxxvii, 180.

D.

- Didymium.—Researches on didymium and its principal compounds : by *C. Marignac*. Ann. Ch. Phys. [3] xxxviii, 148 ; Chem. Soc. Qu. J. vi, 260.
- Digestion.—New researches on the digestion of amylaceous matters, followed by considerations on digestion in general : by *M. Blondlot*. Compt. rend. xxxvii, 753.
- Distillation.—Further examination of the products of the dry distillation of organic bodies : by *C. Völckel*. Ann. Ch. Pharm. lxxxv, 59.
- Dyeing.—Chemical researches on dyeing. Ninth memoir : On the action which solid bodies, while they retain the solid state, may exercise on a liquid which holds a solid or a gas in solution : by *M. Chevreul*. Compt. rend. xxxvi, 981.
- On the introduction of sulphopurpurate of soda (*carmin d'indigo rouge*) into wool and silk dyeing : by *E. Haefely*. Bull. de la Soc. Industr. de Mulhouse, xxiv, 321.—Report thereupon : by *C. Koechlin*. Ibid. 328.
- Method of detecting the dyes which have been used in the dyeing of stuffs. Chem. Gaz. 1853, 218.
- Improvement in the production of the “*Bleu de France*” on wool. J. Fr. Inst. [3] xxv, 69.
- On the applicability of molybdic acid and the molybdates to dyeing and calico-printing : by *W. H. Kurrer*. Chem. Gaz. 1853, 435.
- Dye-stuff.—On a new dye-stuff from China : by *W. Stein*. Chem. Gaz. 1853, 221.
- Dye-stuffs.—Importation of Wurrus. Pharm. J. Trans. xiii, 284.
- Dye-woods.—Preparation of dye-woods (Brazil's Patent). Chem 1853, 19.

E.

- Earths.—On edible earths : by *Dr. Ehrenberg*. J. Pharm. [3] xxiv, 142.
- Electricity.—Distribution of electricity on the surface of bodies : by *M. Bourbouze*. Compt. rend. xxxvi, 616.
- On the law of electrolysis : by *H. Buff*. Ann. Ch. Pharm. lxxxv, 1 ; Chem. Soc. Qu. J. vi, 47.
- On some anomalous cases of electrical decomposition : by *W. R. Grove*. Phil. Mag. [4] v, 203.

- Electricity.—On the motion of liquids in the closed voltaic circuit: by *G. Wiedemann*. Pogg. Ann. lxxxvii, 321.
- On silver as a unit of measure for resistance to electric conduction: by *W. Langsdorf*. Ann. Ch. Pharm. lxxxv, 155.
- Researches on the electric conducting power of gases at high temperatures: by *E. Becquerel*. Compt. rend. xxxvii, 20.
- On the proper conducting power of liquid-circuits without a metal: by *L. Foucault*. Compt. rend. xxxvii, 580.
- Note on the calorific effects of the voltaic circuit, considered with regard to the chemical action by which the current is produced: by *P. A. Favre*. Compt. rend. xxxvi, 342.
- Researches on the conductivity of minerals for voltaic electricity and on the electric light: by *E. Wartmann*. Phil. Mag. [4] v, 12.
- The electrical relations of iron and copper in solutions at different temperatures: by *G. Gore*. Pharm. J. Trans. xiii, 110.
- On the position of alloys and amalgams in the thermo-electric series: by *W. Rollmann*. Pogg. Ann. lxxxix, 90.
- Production of dynamic electricity by the heating and evaporation of liquids: by *M. de Chenot*. Compt. rend. xxxvi, 624.
- On the electric phenomena attributed to the motion of heat: by *J. M. Gauguain*. Compt. rend. xxxvii, 82.
- Note on the cause of the development of electricity by rise of temperature: by *M. Leroux*. Compt. rend. [3] xxxvii, 500.
- On electric phenomena attributed to the motion of heat; in reply to the objections of *M. Leroux*: by *M. Gauguain*. Compt. rend. xxxvii, 653.
- Researches on thermo-electric currents: by *M. Gauguain*. Compt. rend. xxxvi, 612, 645.
- Note on the influence of temperature on the electric state of bodies: by *M. Zaliwski*. Compt. rend. xxxvi, 138.
- On the temperatures of the conductors of electric currents: by *R. Adie*. Phil. Mag. [4] v, 46, 193.
- On the dependence of galvanic ignition on the nature of the surrounding gas, as observed by Grove: by *R. Clausius*. Pogg. Ann. lxxxvii, 501; Phil. Mag. [4] v, 209.
- On transient electric currents: by *W. Thomson*. Phil. Mag. [4] v, 393.
- On certain effects of electric currents: by *A. Masson*. Compt. rend. xxxvi, 1130.
- On the intensity and quantity of electric currents. Phil. Mag. [4] v, 363.
- Facts relating to the electric current and the electric light: by *M. Quet*. Compt. rend. xxxv, 949.
- On a new class of gaseous couples: by *M. Gauguain*. Compt. rend. xxxvii, 584.
- On electric differences, and on Faraday's sulphide of potassium circuit: by *B. Kohlrausch*. Pogg. Ann. lxxxviii, 464.
- Substitution of chlorine for oxygen in Bunsen's battery. Reaction which takes place when hydrochloric is substituted for nitric acid in the ordinary battery: by *M. Leroux*. Compt. rend. xxxvii, 588.

- Electricity.—On the use of heated sulphuric acid and bioxide of manganese in Bunsen's battery: by *M. Leroux*. Compt. rend. xxxvii, 355.
- New arrangement of the voltaic battery: by *M. Guignet*. Compt. rend. xxxvii, 174.
- Cheap method of constructing a galvanic battery: by *W. Symons*. Pharm. J. Trans. xii, 391.
- Tangent-galvanometer with long wire: by *H. Buff*. Ann. Ch. Pharm. lxxxvi, 1.
- Description of a new galvanometer, for the absolute measurement of weak as well as of strong currents: by *M. Lamont*. Pogg. Ann. lxxxviii, 230.
- Description of an electroscope with double condenser: by *M. Gauguain*. Compt. rend. xxxvi, 1084.
- On inductive electrical machines and a means of increasing their effect: by *M. Fizeau*. Compt. rend. xxxvi, 418.
- On the direction of the induced current produced by the discharge of friction-electricity: by *H. Buff*. Ann. Ch. Pharm. lxxxvi, 293.
- On the strength of galvanic polarization: by *W. Beetz*. Pogg. Ann. xc, 42.
- Observations on the electro-chemical properties of hydrogen: by *E. Becquerel*. Ann. Ch. Phys. [3] xxxvii, 355.
- On the electro-chemical deportment of oxygen: by *M. Kard*. Phil. Mag. [4] vi, 241.
- An experimental inquiry undertaken with the view of ascertaining whether any and what signs of current force are manifested during the organic process of secretion in living animals: by *H. F. Baxter*. Phil. Trans. 1852, ii, 279.
- On the solution of urinary calculi in dilute saline fluids at the temperature of the body, by the aid of electricity: by *H. Bence Jones*. Chem. Gaz. 1853, 99.
- On the reduction and electro-chemical application of tungsten, molybdenum, titanium, and silicium: by *Junot de Bussy*. Compt. rend. xxxvi, 540.
- Inductive view of electro-metallic deposition: by *G. Gore*. Pharm. J. Trans. xiii, 21.
- Note on the electric light. Compt. rend. xxxvi, 255.
- On various electrical phenomena: by *M. Quet*. Compt. rend. xxxvi, 1012.
- Method of arranging the batteries of Grove, Bunsen, &c., so that they may be always ready for immediate action, and that the substances by whose action the current is produced, may not suffer alteration when the battery is inactive: by *Th. du Moncel*. Compt. rend. xxxvii, 713.
- Description of a new electrical machine: by *M. Symons*. Pharm. J. Trans. xxxiii, 288.
- Note on a fact relating to the heating of a conducting wire by the electric current: by *F. de la Provostaye* and *P. Desains*. Compt. rend. xxxvii, 749.
- Electrolysis.—On the transference of the irons during electrolysis: by *W. Hittorf*. Pogg. Ann. lxxxix, 177.

- Electroplating.—Process for electroplating China-ware. J. Fr. Inst. [3] xxvi, 137.
- On the recovery of gold and silver from the liquids employed in electroplating and gilding: by *P. Bolley*. Chem. Gaz. 1853, 354; Pharm. J. Trans. xiii, 231.
- Endosmose.—On the permeability of porous vessels of inorganic material: by *A. Morin*. J. Pharm. [3] xxiv, 100.
- Cause of electric endosmose: by *M. Raoult*. Compt. rend. xxxvi, 826.
- Equivalent Volumes.—On the constitution and equivalent-volume of some mineral species: by *T. S. Hunt*. Sill. Am. J. [2] xvi, 203.
- Considerations on the theory of chemical changes, and on the law of equivalent volumes: by *T. S. Hunt*. Sill. Am. J. [2] xv, 226.
- Equivalents.—Remarks on certain equivalent numbers: by *R. Schneider*. Pogg. Ann. lxxxviii, 314.
- Ergot.—On ergot of rye: by *F. L. Winckler*. Pharm. J. Trans. xiii, 86.
- Erica.—Analysis of the ashes of *Erica carnea* and *Calluna vulgaris* Salisb., and of the soils on which they grow: by *C. F. Röthe*. Ann. Ch. Pharm. lxxxvii, 118.
- Ericaceæ.—On the proximate principles contained in the ericaceous family. J. Pharm. [3] xxiii, 476.
- Chemistry of the plants of the ericaceous family: by *F. Rochleder*. Chem. Gaz. 1853, 189.
- Ether.—On the preparation of ether. Pharm. J. Trans. xii, 486.
- Ethers.—On ethers intermediate between the ænanthylic, and the methylic, ethylic and amylic series; and on the constitution of castor-oil alcohol by *A. W. Wills*. Chem. Soc. Qu. J. vi. 307.
- On the decomposition of the cyanic ethers: by *A. Wurtz*. Compt. rend. xxxvii, 180.
- Ethyl.—Combinations of the sulphides of ethyl and methyl with certain metallic chlorides: by *A. Loir*. J. Pharm. [3] xxiv, 251; Ann. Ch. Pharm. lxxxvii, 369; Chem. Gaz. 1853, 361; Compt. rend. xxxvii, 1095.
- Researches on the stannethyls, a series of new organic radicals formed of tin and ethyl: by *C. Löwig*. Ann. Ch. Phys. [3] xxxvii, 343; J. Pharm. [3] xxiii, 234; Chem. Gaz. 1853, 101, 126, 149, 170.
- On the preparation of crude pelargonate of ethyl: by *R. Wagner*. Chem. Gaz. 1853, 144.
- On selenide of ethyl: by *C. A. Joy*. Ann. Ch. Pharm. lxxxvi, 35.
- On some new compounds of tellurethyl: by *Prof. Wöhler*. Chem. Soc. Qu. J. vi, 40; Chem. Gaz. 853, 149.
- Preparation of ethylamine. Ann. Ch. Pharm. lxxxvi, 374.
- On a decomposition-product of tetrethylammonium: by *Prof. Weltzien*. Ann. Ch. Pharm. lxxxvi, 292.
- Evaporation.—Researches on evaporation: by *Prof. Marcet*. Phil. Mag. [4] vi, 385; Compt. rend. xxxvi, 339.
- Explosive Compounds.—Improvements in explosive compounds and fuses for mining and other purposes (Davey and Chance's Patent). Pharm. J. Trans. xii, 354.
- Extracts.—Apparatus for the preparation of extracts *in vacuo*: by *MM. Soubeiran and Goble*. J. Pharm. [3] xxiii, 5.

F.

- Fats.—On the contractions of glycerine with acids, and on the synthesis of the proximate principles of animal fats: by *M. Berthelot*. *Compt. rend.* xxxvii, 398; *J. Pharm.* [3] xxiii, 410; *Chem. Soc. Qu. J.* vi, 280.
- Facts relating to the history of fats: by *J. Lefort*. *Compt. rend.* xxxvii, 28; *J. Pharm.* [3] xxiii, 113.
- On the composition of mutton-fat, human fat and spermaceti (Addendum): by *W. Heintz*. *Pogg. Ann.* lxxxvii, 553.
- On the composition of beef-suet: by *W. Heintz*. *Pogg. Ann.* lxxxvii, 579.
- On Pela or Chinese wax, and on the Chinese vegetable fat called *Fat of Stilligia*: by *C. Martius*. *J. Pharm.* [3] xxiv, 224.
- On the constitution of various fats: by *J. J. Pohl*. *Chem. Gaz.* 1853, 384.
- On the nature of the fat of cantharides: by *Dr. Gössmann*. *Ann. Ch. Pharm.* lxxxvi, 317.
- Comparative examination of the quantities of water and fat in the brain: by *J. Hauff* and *R. Wagner*. *Ann. Ch. Pharm.* lxxxv, 42.
- On the preparation of medicinal oils and fats: by *M. Lhermite*. *J. Pharm.* [3] xxiv, 349.
- Fat for tempering steel. *Rev. Sci.* xlii, 396.
- Fermentation.—Researches on gallic fermentation: by *C. Robiquet*. *J. Pharm.* [3] xxiii, 241.
- Researches on the fermentation of citric acid: by *J. Personne*. *Compt. rend.* xxxvi, 197.
- On chemical substitutes for the fermentation of bread. *Pharm. J. Trans.* xiii, 173.
- Ferrocyanides.—On the mutual action of the two ferrocyanides of potassium and of the nitrate and the simple combustion-products of silver: by *O. B. Kühn*. *Ann. Ch. Pharm.* lxxxvii, 84.
- On the red colouring of quinine by ferrocyanide of potassium: by *A. Vogel*. *Ann. Ch. Pharm.* lxxxvi, 122.
- Fire.—Cheap red fire. *Jahrb. f. pr. Pharm.* xxvi, 321; *Chem. Gaz.* 1853, 385.
- Fish.—Some observations on fish in relation to diet: by *J. Davy*. *Proc. Roy. Soc. Edinb.* 1852-53, 197.
- Flax.—On the gases evolved in steeping flax: by *Prof. Hodges*. *Chem. Gaz.* 1853, 419.
- Fluorine.—On the fluorine-salts of antimony: by *F. A. Flückiger*. *Chem. Gaz.* 1853, 1.
- Forensic Chemistry.—On the errors which may be introduced into chemico-legal investigations by the use of charcoal to decolorize liquids containing poisonous substances: by *H. Bonnemains*. *Compt. rend.* xxxvi, 150. — Remarks on this communication: by *Gauthier de Claubry*. *Ibid.* 224.
- Fossils.—Chemical investigation of the remains of fossil mammalia: by *F. V. Greene*. *Sill. Am. J.* [2] xvi, 16.
- Frog.—On the constituents of the flesh of the frog: by *Fr. Grohé*. *Ann. Ch. Pharm.* lxxxv, 233.

- Fuel.—Mode of preparing mineral combustibles so as to give them the same chemical properties as charcoal: by *A. Chenot*. Compt. rend. xxxvi, 152.
- Fungi.—On the acids contained in fungi: by *P. Bolley*. Ann. Ch. Pharm. lxxxvi, 44; Chem. Gaz. 1853, 291.
- On the acids contained in certain fungi: by *M. Dessaignes*. Compt. rend. xxxvii, 782.
- Furfurol.—On the preparation of furfurol: by *H. Debus*. Ann. Ch. Pharm. lxxxv, 100.
- Fusel-oil.—Examination of the fusel-oil from Indian corn and rye: by *C. M. Wetherill*. Chem. Gaz. 1853, 281; J. Fr. Inst. [3] xxv, 385.

G.

- Galls.—Examination of Bassorah galls: by *L. F. Bley*. Arch. Pharm. lxxv, 138; Chem. Gaz. 1853, 468.
- Gallstones.—Analysis of gallstones: by *A. v. Planta* and *A. Kekulé*. Ann. Ch. Pharm. lxxxvii, 367.
- Gases.—On the Fourth law of the relations of the elastic force, density and temperature of gases: by *R. Potter*. Phil. Mag. [4] vi, 161.
- Researches on the specific heat of elastic fluids: by *V. Regnault*. Pogg. Ann. lxxxix, 335; Phil. Mag. [4] v, 473.
- Memoir on the consequences which may be deduced from Regnault's experiments on the law of compressibility of gases: by *M. Avogadro*. Ann. Ch. Phys. [3] xxxix, 140; J. Fr. Inst. [3] xxv, 44.
- Researches on the electric conducting power of gases at high temperatures: by *E. Becquerel*. Compt. rend. xxxvii, 20.
- Condensation of gases at the surface of solid bodies: by *J. Jamin* and *A. Bertrand*. Compt. rend. xxxvi, 994; Phil. Mag. [4] vi, 156.
- On the condensation of gases at the surface of smooth bodies: by *G. Magnus*. Pogg. Ann. lxxxix, 604; Phil. Mag. [4] vi, 334.
- On an improved apparatus for the analysis of gases: by *E. Frankland* and *W. J. Ward*. Chem. Soc. Qu. J. vi, 197.
- On the gases evolved in the distillation of sugar: by *C. Völckel*. Ann. Ch. Pharm. lxxxvi, 63.
- Analysis of gases contained in the soil. Pogg. Ann. lxxxvii, 616.
- Contributions to the knowledge of the manufacture of gas: by *E. Frankland*. Pharm. J. Trans. xii, 431.
- Improvements in the purification of coal-gas (Losh's Patent). Pharm. J. Trans. xii, 355.
- Improvements in the manufacture of coal-gas (Kirkham's Patent). Pharm. J. Trans. xii, 453.
- Improvements in the manufacture of gas (Vegetable gas) [Booth's Patent]. Pharm. J. Trans. xii, 355.
- The manufacture of gas from wood or turf: by *J. Aycliffe*. Pharm. J. Trans. xiii, 129.
- On the use of gas as fuel in organic analysis: by *A. W. Hofmann*. Chem. Soc. Qu. J. vi, 209.

- Gases.—New gasometer, serving as a pneumatic trough and as an aspirator : by *M. Tiffreau*. *Compt. rend.* xxxvii, 51.
- Description of an apparatus for collecting gases over water or mercury : by *W. M. Williams*. *Chem. Soc. Qu. J.* vi, 44.
- Ginger.—On essential oil of ginger : by *A. Papousek*. *Pharm. J. Trans.* xii, 601.
- Glue.—Note on the preparation of liquid glue : by *S. Dumoulin*. *Pharm. J. Trans.* xii, 392.
- Glycerine.—On the compounds of glycerine with acids, and on the synthesis of the proximate principles of animal fats : by *M. Berthelot*. *Compt. rend.* xxxvii, 398 ; *J. Pharm.* [3] xxiii, 410 ; xxiv, 259 ; *Chem. Soc. Qu. J.* vi, 280 ; *Chem. Gaz.* 1853, 121.
- On the preparation of glycerine : by *C. Morfitt*. *J. Pharm.* [3] xxiv, 357 ; *Pharm. J. Trans.* xiii, 84.
- On the purification of glycerine and its employment in the arts. *Pharm. J. Trans.* xiii, 137.
- Gold.—On the exploitation of gold. *Ann. Min.* [5] iii, 816, 830.
- On the situation and working of gold in Australia : by *M. Delesse*. *Ann. Min.* [5] vi, 179.
- On the occurrence of gold in Pennsylvania : by *J. W. Mallet*. *Phil. Mag.* [4] v, 150.
- On the distribution of gold : by *J. Percy*. *Phil. Mag.* [4] v, 310.
- On auriferous quartz : by *A. B. Northcote*. *Phil. Mag.* [4] vi, 390.
- Separation of gold from arsenical pyrites, according to Plattner's method : by *W. Guettler*. *J. Fr. Inst.* [3] xxvi, 180.
- On the recovery of gold and silver from the liquids employed in electroplating and gilding : by *P. Bolley*. *Chem. Gaz.* 1853, 354.
- Large nugget of gold found in Australia. *Pogg. Ann.* lxxxviii, 176.
- Graduated Solutions.—On improvements in the use of graduated solutions : by *Dr. Mohr*. *Ann. Ch. Pharm.* lxxxvi, 129.
- Grain.—On the value of nutritive grain : by *J. Reiset*. *Ann. Ch. Phys.* [3] xxxix, 22 ; *Compt. rend.* xxxvi, 872.
- Granite.—Researches on granite : by *A. Delesse*. *Phil. Mag.* [4] vi, 206.
- Grape-disease.—On the use of pentasulphide of calcium as a means of preventing the grape-disease : by *A. P. Price*. *Chem. Gaz.* 1853, 414.
- Guano.—Examination of guano : by *M. Melsens*. *Chem. Gaz.* 1853, 120.
- The nitre caverns of the Indian Archipelago, a probable source of guano. *Pharm. J. Trans.* xiii, 136.
- On commercial guano : by *M. Girardin*. *J. Pharm.* [3] xxiv, 118.
- Guaiacum.—Note on extract of guaiacum : by *M. Monigaut*. *J. Pharm.* [3] xxiv, 130.
- Adulteration of guaiacum wood. *Pharm. J. Trans.* xii, 450.
- Gum.—Chemical and pharmacological investigation of gum-kino : by *C. Hennig*. *J. Pharm.* [3] xxiv, 96.
- Gun-barrels.—On the colouring of gun-barrels, and on processes for working on iron and steel. *Rev. Sci.* xlii, 398.
- Gun-cotton.—On the preparation of gun-cotton : by *C. Mann*. *Bull. de St. Petersbourg*, xi, 210 ; *Pharm. J. Trans.* xiii, 71 ; *J. pr. Chem.* lix, 141 ; *J. Pharm.* [3] xxiv, 371.

- Gunpowder.—On a method of determining the quantity of nitrate of potash contained in gunpowder: by *M. Uebatius*. Chem. Gaz. 1853, 433.
- Gutta Percha.—On caoutchouc and gutta percha: by *F. C. Calvert*. Pharm. J. Trans. xii, 423.
- Improvements in the preparation of gutta percha (Rider's Patent). J. Trans. xii, 452.

H.

- Heat.—On the mechanical effect of heat and of chemical forces: by *W. J. M. Rankine*. Phil. Mag. [4] v, 6.
- On the mechanical action of heat: by *W. J. M. Rankine*. Trans. Roy. Soc. Edinb. xx, 591; *abstr.* Proc. Roy. Soc. Edinb. 1852-53, 162.
- Mechanical theory of heat.—Specific heat of air: by *W. J. M. Rankine*. Phil. Mag. [4] v, 437.
- Mechanical theory of heat.—Velocity of sound in gases: by *W. J. M. Rankine*. Phil. Mag. [4] v, 483.
- Observations on heat and its theories: by *A. J. Angström*. Pogg. Ann. lxxxviii, 165.
- On the elevation and depression of temperature, produced in permanent gases, by compression and dilatation, and by contact with bodies at various temperatures: by *J. H. Koosen*. Pogg. Ann. lxxxix, 437.
- Hassler's experiments on the expansion of water at various temperatures: by *J. H. Alexander*. Sill. Am. J. [2] xvi, 170.
- Addition to a memoir entitled "Researches on the relations between the atomic weight and specific heat of elementary bodies": by *M. Granier*. Compt. rend. xxxvii, 130.
- Researches on the specific heat of elastic fluids: by *V. Regnault*. Pogg. Ann. lxxxix, 335; Phil. Mag. [4] v, 473; Compt. rend. xxxvi, 676.
- On the specific heat of red phosphorus: by *V. Regnault*. Pogg. Ann. lxxxix, 495; Ann. Ch. Phys. [3] xxxviii, 131.
- Researches on the quantities of heat disengaged in chemical and molecular actions (3rd, 4th, and 5th parts—Conclusion): by *P. A. Favre* and *J. T. Silbermann*. Ann. Ch. Phys. [3] xxxvii, 406; abstract of the whole series, Chem. Soc. Qu. J. vi, 235.
- Thermo-chemical researches on compounds formed in multiple proportions: by *P. A. Favre*. J. Pharm. [3] xxiv, 241.
- On the heat of chemical combination: by *T. Woods*. Phil. Mag. [4] v, 10.
- On the heat evolved when sulphur-crystals, obtained by fusion, pass into the other form: by *E. Mitscherlich*. Pogg. Ann. lxxxviii, 328.
- Equilibrium of temperature within envelopes. Researches on the radiating power of rock-salt: by *Provostaye* and *Desains*. Compt. rend. xxxvi, 84.
- Researches on diathermanous bodies: by *M. Melloni*. Compt. rend. xxxvi, 709.
- Researches on diathermanous substances. Remarks on a communication by MM. de la Provostaye and Desains: by *M. Melloni*. Compt. rend. xxxvii, 590.— Observations on M. Melloni's communication: by *MM. de la Provostaye* and *Desains*. Ibid. 669.

- Heat.**—Reflection of invisible heat from glass and rock-salt: by *Provostaye* and *Desains*. *Compt. rend.* xxxvii, 168.—Note on the preceding: by *M. Melloni*. *Ibid.* 293.
- Reply to a letter of *M. Melloni* on the transmission of heat through rock-salt: by *Provostaye* and *Desains*. *Compt. rend.* xxxvi, 1073.
- On the heat-conducting power of metals: by *G. Wiedermann* and *R. Franz*. *Pogg. Ann.* lxxxix, 497.
- Thermic conduction in metals: by *G. Gore*. *Phil. Mag.* [4] vi, 382.
- On the heat-conduction of metals: by *H. J. Gouillaud*. *Pogg. Ann.* lxxxviii, 163.
- Experiments on the relative heat-conducting power of certain rocks: by *G. v. Helmersen*. *Pogg. Ann.* lxxxviii, 461.
- Researches on the temperature of the earth at great depths: by *M. Walferdin*. *Compt. rend.* xxxvi, 250.
- On the absolute zero of the perfect gas thermometer, being a note to a paper on the mechanical action of heat: by *W. J. M. Rankine*. *Trans. Roy. Soc. Edinb.* xx, 561; *abstr.* *Proc. Roy. Soc. Edinb.* 1852-53, 160.
- Proof of a sensible difference between the mercurial and air-thermometers, from 0° to 100° C.: by *J. Waterston*. *Phil. Mag.* [4] v, 63.
- Fundamental principles of a system of thermo-chemistry: by *J. Thomson*. *Pogg. Ann.* lxxxviii, 349.
- On the electric phenomena attributed to the motion of heat: by *J. M. Gaugain*. *Compt. rend.* xxxvii, 82.
- On the temperatures of the conductors of electric currents: by *R. Adie*. *Phil. Mag.* [4] v, 46, 209.
- On the dependence of the heating power of the galvanic current on the nature of the surrounding gas: by *R. Clausius*. *Phil. Mag.* [4] v, 209.
- Note on the influence of temperature on the electric state of bodies: by *M. Zaliwski*. *Compt. rend.* xxxvi, 138.
- Action of heat on oil of turpentine: by *M. Berthelot*. *Ann. Ch. Phys.* [3] xxxix, 5.
- On the precautions to be observed in heating substances in close vessels: by *M. Berthelot*. *J. Pharm.* [3] xxiii, 357.
- Temperature at the bottom of the artesian well at Mendorf: by *M. Walferdin*. *Pogg. Ann.* lxxxix, 349.
- Helix.**—Analysis of the operculum of the shell of *Helix pomatia*: by *M. Wicke*. *Ann. Ch. Pharm.* lxxxvii, 221.
- Hellebore.**—On the occurrence of a crystallizable substance in black hellebore: by *W. Bastick*. *Pharm. J. Trans.* xii, 174; *J. Pharm.* [3] xxiv, 159.
- Hops.**—On oil of hops: by *R. Wagner*. *J. pr. Chem.* lviii, 6; *Chem. Gaz.* 1853, 272.
- Horn.**—On the products of the decomposition of certain horny substances: by *A. C. Leyer* and *Köller*. *J. pr. Chem.* lviii, 273; *Chem. Gaz.* 1853, 348.
- Humuline.**—On the manufacture of humuline. *Pharm. J. Trans.* xiii, 231.
- Hydrocarbons.**—On a process for ascertaining the equivalents of some fluid hydrocarbons by means of bromine. *Chem. Gaz.* 1853, 365.

- Hydrochlorates.—On hydrochlorate of oil of turpentine : by *M. Berthelot*. Ann. Ch. Phys. [3] xxxvii, 223.
- Hydrogen.—Observations on the electro-chemical properties of hydrogen : by *E. Becquerel*. Ann. Ch. Phys. [3] xxxvii, 385.
- On a new oxide of hydrogen, and its relation to ozone : by *M. Baumert*. Pogg. Ann. lxxxix, 37 ; Phil. Mag. [4] vi, 51 ; *abstr.* Chem. Soc. Qu. J. vi, 169.
- On the use of hydrogen in determining vapour-densities, and on the acidification of alcohols by oxygen gas or atmospheric air : by *R. Railton*. Chem. Soc. Qu. J. vi, 205.
- On the formation of hydrogen and its homologues : by *B. C. Brodie*. Chem. Gaz. 1853, 297.
- On a modification of hydrogen : by *G. Osann*. J. Pr. Chem. lviii, 385 ; Chem. Gaz. 1853, 385.
- Hygiène.—On certain chemical reactions connected with the hygiène of populous cities : by *M. Chevreul*. Compt. rend. xxxvi, 553.
- Hygrometry.—Researches on hygrometry : by *V. Regnault*. Ann. Ch. Phys. [3] xxxvii, 257 ; Compt. rend. xxxv, 930 ; Pogg. Ann. lxxxviii, 420.
- Hypochlorites.—On a new method of estimating the value of chloride of lime : by *Dr. Penot*. Bull. de la Soc. Ind. de Mulhouse, xxiv, 246 ; Chem. Gaz. 1853, 217.
- On a new method for determining the amount of available chlorine in hypochlorites : by *A. P. Price*. Chem. Gaz. 1853, 419.
- On hypochlorite of magnesia as an antidote to phosphorus : by *M. Bechert*. J. Pharm. [3] xxiv, 352 ; Pharm. J. Trans. xii, 603.

I.

- Incrustation.—Simple means of preventing the formation of incrustations in boilers : by *R. Fresenius*. J. pr. Chem. lviii, 65 ; Chem. Gaz. 1853, 333.
- Indigo.—On the introduction of sulphopurpurate of soda (*carmin d'indigo rouge*) into wool and silk dyeing : by *E. Haefely*. Bull. de la Soc. Industr. de Mulhouse, xxiv, 321.—Report thereupon : by *C. Koechlin*. Ibid. 328.
- On the action of soda on the sulphuric compounds of indigo : by *C. Gros-Renaud, Jun.* Bull. de la Soc. Industr. de Mulhouse. xxiv, 343.
- Process for imparting greater liveliness to indigo-blue in stuffs : by *L. Guillonet*. J. Fr. Inst. [3] xxv, 55.
- On the determination of the value of commercial indigo : by *E. Wittstein*. Chem. Gaz. 1853, 135 ; Pharm. J. Trans. xii, 449.
- On the frequent occurrence of indigo in human urine, and on its chemical and physiological relations : by *A. H. Hassall*. Chem. Gaz. 1853, 355 ; Pharm. J. Trans. xiii, 219.
- Ink.—Ink for steel pens : by *F. Runge*. J. Pharm. [3] xxiv, 57.
- Red ink. Pharm. J. Trans. xii, 601.
- Iodides.—On the constitution of iodide of nitrogen : by *R. Bunsen*. Ann. Ch. Pharm. lxxxiv, 1 ; Ann. Ch. Phys. [3] xxxix, 74 ; *abstr.* Chem. Soc. Qu. J. vi, 90 ; J. Pharm. [3] xxiii, 393.

Iodides.—Proto-iodide of tin. *Ann. Ch. Pharm.* lxxxvi, 374.

Iodine.—On the general distribution of iodine: by *Stevenson Macadam*. *Chem. Soc. Qu. J.* vi, 166; *Pharm. J. Trans.* xiii, 178.

— On the distribution of iodine: by *Prof. Sigwart*. *Wurt. Natur. Jahresber.* xix, 43; *Chem. Gaz.* 1853, 228.

— On the existence of iodine in various plants: by *Stevenson Macadam*. *J. Pharm.* [3] xxiii, 317.

— On the pretended occurrence of iodine in milk, eggs, and the atmosphere: by *D. Lohmeyer*. *Phil. Mag.* [4] vi, 237; *Pharm. J. Trans.* xiii, 179.

— Note on the small quantity of iodine contained in the water of the Almendares River (Havannah), and in the land-plants, and the atmosphere of that country: by *M. Casaseca*. *Compt. rend.* xxxvii, 348.

— Facts relating to the history of iodine: by *M. Barreswil*. *J. Pharm.* [3] xxiv, 346.

— Preliminary notice on a mineral water containing iodine: by *P. Bolley*. *Ann. Ch. Pharm.* lxxxvi, 51.

— On the qualitative and quantitative determination of iodine and its separation from bromine and chlorine: by *E. Moride*. *Chem. Gaz.* 1853, 75.

— On the determination of iodine: by *R. Kersting*. *Ann. Ch. Pharm.* lxxxvii, 19.

— On a quick approximative method of estimating minute quantities of iodine: by *T. J. Herapath*. *Phil. Mag.* [4] vi, 185.

— On tests for iodine: by *A. Overbeck*. *J. Pharm.* [3] xxiv, 72; *Pharm. J. Trans.* xiii, 180.

— Method of detecting the presence of water in iodine. *Pharm. J. Trans.* xiii, 181.

— On the estimation of water in commercial iodine: by *M. Bolley*. *Chem. Gaz.* 1853, 119.

— Reproduction of engravings and drawings by means of iodine-vapour: by *Niepcé de St. Victor*. *Compt. rend.* xxxvi, 581.

— On the iodoquinine compound, investigated in its optical relations by Dr. Herapath and Prof. Stokes: by *W. Haidinger*. *Phil. Mag.* [4] vi, 273.

— On the preparation of hydriodate of ammonia. *J. Pharm.* [3] xxiv, 35.

— Presence of iodine in rain-water, running water, and in plants from the Antilles and from the coasts of the Mediterranean: by *Ad Chatin*. *Compt. rend.* xxxvii, 723.

Iridium.—On some new compounds of iridium: by *M. Skohlikoff*. *Bull. de St. Petersb. Ch. Phys. Math. Classe* xi, 25; *Chem. Gaz.* 1853, 29.

— On a probably new element with iridosmine and platinum: by *A. F. Genth*. *Sill. Am. J.* [2] xv, 246; *Chem. Gaz.* 1853, 145.

Iron.—Native iron in the Mühlhausen Keuper formation: by *J. G. Bornemann*. *Pogg. Ann.* lxxxviii, 145, 325.

— On the meteoric iron of Gütersloh. *Pogg. Ann.* lxxxvii, 500.

— Notice of meteoric iron near Lion River, Great Namaqualand, S Africa, and on the detection of potassium in meteoric iron: by *C. U. Shephard*. *Sill. Am. J.* [2] xv, 1.

- Iron.—Analysis of meteoric iron from Cosby's Creek : by *C. A. Joy*. Ann. Ch. Pharm. lxxxvi, 39.
- Notice of the meteoric iron found near Seneca River, Cayuga County, N. Y. : by *C. U. Shephard*. Sill. Am. J. [2] xv, 363 ; Pogg. Ann. lxxxviii, 176.
- On a new iron-deposit from Obergrund near Zuckmantel : by *E. F. Glocker*. Pogg. Ann. lxxxix, 48.
- On minerals accompanying chromic iron : by *T. H. Garrett*. Sill. Am. J. [2] xv, 332.
- On the analysis of cast-iron : by *C. Morfitt* and *J. C. Booth*. Chem. Gaz. 1853, 368, 388, 411 ; J. Fr. Inst. [3] xxv, 193, 247.
- Analysis of pig-iron and bog-iron-ore : by *H. L. Buff*. Ann. Ch. Pharm. lxxxiii, 376 ; Chem. Gaz. 1853, 276.
- On an iron-ore containing vanadium. Ann. Ch. Pharm. lxxxvi, 127.
- On the new method employed for the manufacture of iron in the forests of Carinthia : by *M. le Plaq.* Ann. Min. [5] iii, 46.
- Remarks on the structural conditions of iron : by *T. R. v. Fuchs*. Phil. Mag. [4] v, 389 ; Chem. Gaz. 1853, 94.
- On the increased strength of cast-iron produced by the use of improved coke : by *W. Fairbairn*. Chem. Gaz. 1853, 158 ; J. Fr. Inst. [3] xxv, 375.
- On the separation of manganese from iron and nickel : by *T. Schiel*. Chem. Gaz. 1853, 413.
- On the purification of iron and coke from sulphur. J. Fr. Inst. [3] xxv, 47.
- On the estimation of iron by volume-analysis : by *T. J. Herapath*. Chem. Gaz. 1853, 294.
- Passive state of nickel and iron : by *J. Nicklès*. Pogg. Ann. xc, 351.
- On the estimation of protoxide of iron by the method of volumes ; by *M. Oppermann*. J. Pharm. [3] xxiii, 294.
- On the compounds of boracic acid and water with sesquioxide of iron : by *H. Rose*. Pogg. Ann. lxxxix, 473.
- Action of protosalts of iron on pyroxylin and its congeners : by *M. Béchamp*. Compt. rend. xxxvii, 134.
- On the impurities in commercial oxide of iron : by *M. Wackenroder*. J. Pharm. [3] xxiii, 240.
- Comparative experiments with hydrate of magnesia and hydrated sesquioxide of iron as antidotes for arsenic : by *K. D. Schroff*. N. Repert. Pharm. i, 47 ; J. Pharm. [3] xxiii, 230 ; Pharm. J. Trans. xiii, 38.
- Preparation of ammonio-chloride of iron. Pharm. J. Trans. xii, 450.
- Preparation of lactate of protoxide of iron : by *Thirault de St.-Etienne*. J. Pharm. [3] xxiii, 183.
- On the adulteration of the citrate of iron and quinine of commerce : by *C. G. Williams*. Chem. Gaz. 1853, 269.
- On iron and some improvements in its manufacture : by *J. D. Stirling*. J. Fr. Inst. [3] xxvi, 36, 93.
- Processes for working on iron and steel. Rev. Sci. xlii, 398.
- Composition for engraving on iron and steel. Rev. Sci. xlii, 405.
- Syrup of pyrophosphate of iron : by *M. Soubeiran*. J. Pharm. [3] xxiii, 62.

- Isomerism.**—Contributions to the chemical history of isomeric acids: by *J. Gottlieb*. *Ann. Ch. Pharm.* lxxxv, 17.
 — On the isomeric modifications of sulphide of antimony. *Pogg. Ann.* lxxxix, 122.
Isomorphism.—On the isomorphism of Sphene and Euclase: by *J. D. Dana*. *Sill. Am. J.* [2] xvi, 96.
Ivory.—Improvements in producing ornamental surfaces in metal, ivory, or bone (Skinner's Patent). *Chem. Gaz.* 1853, 59.

J.

- Jalap.**—On jalap-root: by *G. Meyer*. *Ann. Ch. Phys.* [3] xxxvi, 495;
J. Pharm. [3] xxii, 463.

K.

- Kino.**—Chemical and pharmacological examination of kino. *Pharm. J. Trans.* xxii, 80.
 — On a new source of kino: by *R. Christison*. *Pharm. J. Trans.* xii, 377.

L.

- Lactates.**—Preparation of lactate of protoxide of iron: by *Thirault de St.-Etienne*. *J. Pharm.* [3] xxiii, 183.
 — On the preparation of lactate of protoxide of iron: by *M. Thibault*. *Pharm. J. Trans.* xiii, 85.
Lakes.—On the preparation of lakes by means of chloride of antimony. *Schweiz. Gewerbeblatt* xi, 127; *Chem. Gaz.* 1853, 276.
Lanthanum.—On the occurrence of crystallized carbonate of lanthanum: by *W. P. Blake*. *Sill. Am. J.* [2] xvi, 228.
Lard.—American lard: by *F. C. Calvert*. *Pharm. J. Trans.* xii, 388.
Lead.—On tungstate of lead or Scheele's tinge: by *E. J. Chapman*. *Phil. Mag.* [4] vi, 120.
 — On the compounds of boracic acid and water with oxide of lead: by *H. Rose*. *Pogg. Ann.* lxxxvii, 470.
 — On the desilverizing of argentiferous lead by means of zinc: by *Dr. Karsten*. *Chem. Gaz.* 1853, 132.
Ledum.—On *Ledum palustre*: by *F. Rochleder* and *R. Schwartz*. *Chem. Gaz.* 1853, 13.
Leucin.—Test for leucin and tyrosin: by *Reinhold Hoffmann*. *Ann. Ch. Pharm.* lxxxvii, 123.
Light.—On the change of refrangibility of light: by *G. Stokes*. *Phil. Trans.* 1852, ii, 463.
 — On the chemical action of the solar radiations: by *R. Hunt*. *Chem. Gaz.* 1853, 415.
 — On the cause of the luminosity of certain bodies when heated: by *Prof. Schrötter*. *Chem. Gaz.* 1853, 312.

- Light.**—On the optical phenomena and crystallization of tourmaline, titanium and quartz, within mica, amethyst, and topaz: by *D. Brewster*. Trans. Roy. Soc. Edinb. xx, 547; Phil. Mag. [4] vi, 265; *abstr.* Proc. Roy. Soc. Edinb. 1852-53, 158.
- Observations, economical and sanitary, on the employment of chemical light for artificial allumination: by *E. Frankland*. J. Fr. Inst. [3] xxvi, 21.
- On the cause of the luminosity of certain bodies when heated: by *A. Schrötter*. Pharm. J. Trans. xiii, 293.
- Lignites.**—On peculiar lignites containing wax: by *L. Bruckner*. J. pr. Chem. lvii, 1; J. Pharm. [3] xxiii, 391.
- Lime.**—Note on the consolidation of stalactites and of calcareous strata: by *M. Fournet*. Compt. rend. xxxvi, 387.
- On the use of burnt lime instead of limestone as a flux in blast-furnaces: by *E. Montefiore-Levi* and *E. Schmidt*. Chem. Gaz. 1853, 76.
- New method of determining the value of chloride of lime: by *Dr. Penot*. Bull. de la Soc. Industr. de Mulhouse, 1852, No. 118; Chem. Gaz. 1853, 217.
- On the effect of sulphate of lime on vegetable substances: by *M. Clausen*. Chem. Gaz. 1843, 437.
- Limestone.**—Analysis of two limestones: by *A. v. Planta* and *A. Kekulé*. Ann. Ch. Pharm. lxxxvii, 366.
- On the saccharoidal limestone of the gneiss of the Vosges: by *M. Delesse*. Bull. de la Soc. Industr. de Mulhouse, xxiv, 55.
- Linen.**—On the detection of cotton in unbleached linen: by *O. Zimmermann*. Chem. Gaz. 1853, 99.
- On the detection of silk, wool, linen, and cotton fibres in textile fabrics: by *G. C. Wittstein*. Pharm. J. Trans. xiii, 181.
- Liquids.**—Phenomena exhibited by certain liquids when thrown in drops on the surface of an ether: by *M. Sire*. Compt. rend. xxxvii, 657.
- Lithia.**—On the preparation of lithia from triphyline: by *Hugo Müller*. Ann. Ch. Pharm. lxxxv, 251.
- Litmus.**—Action of carbonic and boracic acid on tincture of litmus: by *J. Malaguti*. Ann. Ch. Phys. [3] xxxvii, 206.
- Litter.**—Third note on litters and on the effects of lime: by *M. Payen*. Compt. rend. xxxvii, 93.
- On earthy litter for cattle: by *M. Payen*. Compt. rend. xxxvi, 1017.
- On marly litter: by *C. Brame*. Compt. rend. xxxvii, 17.
- Lucifers.**—Manufacture of lucifer matches. J. Fr. Inst. [3] xxvi, 138.
- On the composition of instantaneous light matches. Pharm. J. Trans. xii, 426.

M.

- Madder.**—On the constitution of the colouring matters of madder: by *E. Schunck*. Phil. Mag. [4] vi, 187.
- On madder-root: by *F. Rochleder*. J. pr. Chem. lvi, 85; J. Pharm. [3] xxii, 470.
- New method of purifying and concentrating the colouring matter of madder (Hughes' Patent). Chem. Gaz. 1853, 380.

Magnesia.—On the preparation of pure magnesia: by *H. Wurtz*. J. Pharm. [3] xxiv, 208.

— Comparative experiments with hydrate of magnesia and hydrated sesquioxide of iron as antidotes for arsenic: by *K. D. Schroff*. N. Repert. Pharm. i, 47; J. Pharm. [3] xxiii, 230; Pharm. J. Trans. xiii, 38.

— On hypochlorite of magnesia as an antidote to phosphorus: by *M. Bechert*. J. Pharm. [3] xxiv, 352.

— Note on the hydrate of chloride of magnesium, melted and in powder: by *M. Casaseca*. Compt. rend. xxxvii, 350.

— On the analysis of mineral waters containing chloride of magnesium: by *M. Tillmanns*. J. Pharm. [3] xxiii, 234.

Magnetism.—On the action of magnetism on a rectilineally polarized ray in its passage through compressed glass: by *Prof. Edbrund*. Ann. Ch. Pharm. lxxvii, 338.

Malates.—On the presence of malate of lime in the leaves of the common ash: by *M. Garot*. J. Pharm. [3] xxiv, 308.

Manganese.—On the volumetric determination of manganese-compounds: by *G. Krieger*. Ann. Ch. Pharm. lxxxvii, 257.

— On a new method for determining the commercial value of oxide of manganese: by *A. P. Price*. Chem. Gaz. 1853, 416.

— On the separation of manganese from nickel and iron: by *T. Schiel*. Chem. Gaz. 1853, 415.

— Note on the colour exhibited by protosalts of manganese: by *A. Gergen*. Compt. rend. xxxvi, 851.

— On phosphide of manganese and permanganic acid. Ann. Ch. Pharm. lxxxvi, 371.

— Preparation of permanganate of potash. Pharm. J. Trans. xiii, 45.

— Separation of manganese from other metals: by *W. Gibbs*. Ann. Ch. Pharm. lxxxv, 52.

— On the occurrence of *Manganspath* in Nassau: by *F. Sandberger*. Pogg. Ann. lxxxviii, 491.

— On the volumetric determination of manganese: by *G. Krieger*. Ann. Ch. Pharm. lxxxvii, 257.

Manure.—Fourth note on various agents for preserving urine and components of the blood for manure: by *M. Payen*. Compt. rend. xxxvii, 473.

— On the power of soils to absorb manure: by *J. T. Way*. Pharm. J. Trans. xii, 542; xiii, 32.

— On the influence of iodized manure (marine manure) in preserving the vine from the attacks of the *Oidium Tuckeri*, and on the peculiar properties of the wine produced by vines thus treated: by *M. Rivet*. Compt. rend. xxxvii, 724.

Membrane.—Observations on the mucous membrane of the intestines: by *Dr. Prevost*. J. Pharm. [3] xxiii, 25.

Membranes.—Experiments on the permeability of membranes by nutritive substances: by *M. Morin*. J. Pharm. xxiii, 10.

Mercury.—On the compounds of the two acids of selenium with the two oxides of mercury, and on native mercurous selenite (Onofrite): by *F. Köhler*. Pogg. Ann. lxxxix, 146.

Mercury.—On several new sulphites of mercuric oxide: by *L. Péan de St. Gilles*. *J. Pharm.* [3] xxiii, 45; *Compt. rend.* xxxvi, 1086.—Remarks thereupon: by *M. Chevreul*. *Ibid.* 1089.

— On the compounds of basic mercurous nitrate with other nitrates: by *G. Stüdeker*. *Ann. Ch. Pharm.* lxxxvii, 129.

— On the composition of phosphate of mercury: by *R. Brandes*. *J. Pharm.* [3] xxiv, 80.

— On selenide of mercury from the Hartz: by *C. Rammelsberg*. *Pogg. Ann.* lxxviii, 319; *Phil. Mag.* [4] vi, 272.

— Method of estimating the value of red cyanide of mercury: by *F. Liesching*. *J. Pharm.* [3] xxiv, 272.

— On some double salts of cyanide of mercury: by *G. Kohl* and *A. Swoboda*. *Chem. Gaz.* 1853, 70.

— On Hahnemann's mercurial precipitate. *J. Pharm.* [3] xxiii, 415.

— On the permeability of metals to mercury: by *J. Nicklès*. *J. Pharm.* [3] xxiii, 50; *Pogg. Ann.* lxxxviii, 335; *Chem. Gaz.* 1853, 89.

Metals.—On the heat-conduction of metals: by *H. J. Gouillaud*. *Pogg. Ann.* lxxxviii, 163.

— On the heat-conducting power of metals: by *G. Wiedemann* and *R. Franz*. *Pogg. Ann.* lxxxix, 497.

— Thermic conduction in metals: by *G. Gore*. *Phil. Mag.* [4] vi, 382.

— Note on the nature of metals: by *M. Tiffereau*. *Compt. rend.* xxxvii, 579.

— On some peculiar reduction of metals in the humid way. *Ann. Ch. Pharm.* lxxxv, 253.

— On the permeability of metals to mercury: by *J. Nicklès*. *Compt. rend.* xxxvi, 154; *J. Pharm.* [3] xxiii, 50; *Pogg. Ann.* lxxxviii, 335; *Chem. Gaz.* 1853, 89.

— On a new series of organic bodies containing metals: by *E. Frankland*. *Phil. Trans.* 1852, ii, 417; *Phil. Mag.* [4] v, 159, 239; *Ann. Ch. Pharm.* lxxxv, 329; *abstr. Chem. Soc. Qu. J.* vi, 57.

— On the metalliferous veins of Aveyron, and their relation to various products of plutonic action: by *A. Boisse*. *Ann. Min.* [5] iii, 467.

— Improved compositions for preventing the oxidation of metals, &c. (Cook's Patent). *Pharm. J. Trans.* xiii, 234.

— Improvements in producing ornamental surfaces in metal, ivory, or bone (Skinner's Patent). *Chem. Gaz.* 1853, 59.

— Improvements in saline and metallic compounds (Claussen's Patent). *Chem. Gaz.* 1853, 20.

— On the principal metallic compositions useful to the armourer. *Rev. Sci.* xlii, 390.

Meteorite.—On the meteoric iron of Gütersloh. *Pogg. Ann.* lxxxvii, 500.

— Analysis of meteoric iron from Cosby's Creek: by *C. A. Joy*. *Ann. Ch. Pharm.* lxxxvi, 39.

— Nature of the meteoric iron found near Seneca River, Cayuga County, N.Y.: by *C. U. Shephard*. *Sill. Am. J.* [2] xv, 363.

— Notice of meteoric iron near Lion River, Great Namaqualand, S. Africa, and on the detection of potassium in meteoric iron: by *C. U. Shephard*. *Sill. Am. J.* [2] xv, 1.

- Meteorite.**—On a supposed meteoric stone, alleged to have fallen in Hampshire, in September, 1852: by *G. Wilson*. *Proc. Roy. Soc. Edinb.* 1852-53, 147.
- Notice of Prof. Clark's thesis on metallic meteorites. *Sill. Am. J.* [2] xv, 7.
- Methyl.**—On the compounds of the sulphides of ethyl and methyl with certain metallic chlorides: by *A. Loir*. *J. Pharm.* [3] xxiv, 251; *Ann. Ch. Pharm.* lxxxvii, 369; *Chem. Gaz.* 1853, 361; *Compt. rend.* xxxvi, 1095.
- Researches on stanmethyl, a new organic radical: by *A. Cahours* and *A. Riche*. *Compt. rend.* xxxvi, 1001.
- Methylamine.**—On the presence of methylamine on the products accompanying acetone: by *C. G. Williams*. *Chem. Gaz.* 1853, 409.
- Mildew.**—On mildew: by *F. C. Calvert*. *Pharm. J. Trans.* xiii, 283.
- Milk.**—Facts relating to the chemical history of milk: by *J. Girardin*. [3] xxiii, 401.
- On the composition of milk: by *MM. Vernois* and *A. Becquerel*. *Compt. rend.* xxxvi, 187; *Chem. Gaz.* 1853, 164.
- On the reaction of fresh milk: by *J. Schlossberger*. *Ann. Ch. Pharm.* lxxxvii, 317.
- Note on the presence, in healthy milk, of an albuminoid principle, which turns the plane of polarization to the left: by *Dovere* and *Poggiato*. *Compt. rend.* xxxvi, 430.
- On the presence of albumin in milk in the normal state: by *M. Quévenne*. *J. Pharm.* [3] xxiv, 94.
- Note on milk: abnormal secretion of albumin by the mammary gland. by *J. Girardin*. *Compt. rend.* xxxvi, 753.
- Remarkable examples of lacteal secretion.—Analysis of the milk in two abnormal cases: by *MM. Joly* and *Filhol*. *Compt. rend.* xxxvi, 571.
- On the so-called *Hexenmilch*, a secretion from the mammary glands of new-born infants: by *J. Schlossberger*. *Ann. Ch. Pharm.* lxxxvii, 324.
- Note on the estimation of sugar of milk, and on the means of detecting adulterations in milk.
- Minerals.**—On the classification of minerals: by *E. J. Chapman*. *Phil. Mag.* [4] vi, 175.
- On the constitution and equivalent volume of some mineral species: by *T. S. Hunt*. *Sill. Am. J.* [2] xvi, 203.
- Artificial formation of minerals: by *N. J. Mauross*. *Sill. Am. J.* [2] xvi, 186.
- On the formation of crystallized minerals: by *A. Dröevermann*. *Ann. Ch. Pharm.* lxxxvii, 126.
- Researches on the conductivity of minerals for voltaic electricity: by *E. Wartmann*. *Phil. Mag.* [4] v, 12.
- New and ready method of determining the alkalis in minerals: by *J. L. Smith*. Part. I. *Sill. Am. J.* [2] xv, 234; xvi, 53; *Chem. Gaz.* 1853, 252, 333.
- Mineralogical notices: On Stauroilite, Calcite; on absorption of water by chalk; on Tungstate of Lead or Scheelite; and on Tinstone pseudomorphs: by *E. J. Chapman*. *Phil. Mag.* [4] vi, 115.

- Minerals.—Contributions to mineralogy: On Tetradymite, Grey Copper, Apophyllite, Allanite, Owenite, Kämmererite (emerald nickel): by *F. A. Genth*. Sill. Am. J. [2] xvi, 81, 167.
- Re-examination of American minerals: by *J. L. Smith* and *G. J. Brush*. Part. I. Emerylite, Euphyllite, Litchfield Mica, Unionite, Kerolite, Bowenite, Williamsite, Lancasterite, Hydromagnesite, Magnesite: Sill. Am. J. [2] xv, 207.—Part II. Chesterlite, Loxoclaste, Danbury Felspars, Haddam Albite, Greenwood Mica, Biotite, Margarodite, Chesterlite Talc, Rhodophyllite, Cumingtonite, Hydrous Anthophyllite, Mourolite, Ozarkite, Dysyntribite, Gibbsite, Emerald Nickels: Sill. Am. J. [2] xvi, 41.
- Notices of the rarer minerals and new localities in Western North Carolina: Diamond, Gold, Emery, Amethyst, Chalcedonic Quartz, Lazulite, Kyanite, Leopardite: by *C. L. Hunter*. Sill. Am. J. [2] xv, 373.
- New minerals from Norway. Pt. IV. (Tachyaphalite and Erdmannite): by *N. J. Berlin*. Pogg. Ann. lxxxviii, 160.
- Chemico-mineralogical researches: by *E. Schmid*.—On the basaltic rocks of the Rhön. Pogg. Ann. lxxxix, 291.
- On minerals accompanying chromic iron: by *T. H. Garrett*. Sill. Am. J. [2] xv, 332.
- Basalt.—On the structure and composition of certain Basaltic and Metamorphic rocks: by *T. Andrews*. Ann. Ch. Pharm. lxxxv, 172; Pogg. Ann. lxxxviii, 321.
- Examination of the basaltic rocks of the Rhön: by *E. Schmid*. Pogg. Ann. lxxxix, 291.
- Cerite.—On the composition of Cerite: by *Theodor Kjerulf*. Ann. Ch. Pharm. lxxxvii, 12.
- Chiviatite.—On Chiviatite, a new mineral from Peru: by *C. Rammelsberg*. Pogg. Ann. lxxxviii, 320; Phil. Mag. [4] v, 457.
- Copper.—On the crystalline form of the Grey Copper of Monzaia: by *M. Delesse*. Ann. Min. [5] iii, 657.
- Dolomite.—Additional observations on the Dolomite of the Franconian Jura, and on the transformation of minerals: by *F. Pffaff*. Pogg. Ann. lxxxvii, 600.
- Euclase.—Monograph on Euclase: by *J. Schabus*. Pogg. Ann. lxxxviii, 608.
- Analysis of euclase: by *J. W. Mallet*. Phil. Mag. [4] v, 127.
- On the isomorphism of Sphene and Euclase: by *J. D. Dana*. Sill. Am. J. [2] xvi, 96.
- Granite.—On the Granite of the Vosges: by *M. Delesse*. Ann. Min. [5] iii, 369.
- Grauwacke.—On the Grauwacke of the Vosges: by *M. Delesse*. Ann. Min. [5] iii, 747.
- Greenockite.—On an artificial production of Greenockite, and of some other compounds of Cadmium: by *E. Schüller*. Ann. Ch. Pharm. lxxxvii, 34.
- Hayesine.—Analysis of Hayesine: by *A. Deck*. Phil. Mag. [4] vi, 50.

- Minerals: Manganese-spar.**—On the occurrence of Manganese-spar in Nassau: by *F. Sandberger*. Pogg. Ann. lxxxviii, 491.
- Mosandrite.**—On the composition of Mosandrite: by *N. J. Berlin*. Pogg. Ann. lxxxviii, 156.
- Oligoclase**—Analysis of Oligoclase from the neighbourhood of Wolfach in the Kinzigthal: by *J. Moser*. Ann. Ch. Pharm. lxxxv, 97.
- Onofrite.**—On native mercurous Selenite (Onofrite): by *F. Köhler*. Pogg. Ann. lxxxix, 146.
- Owenite.**—On Owenite, a new mineral from the Potomac River: by *F. A. Genth*. Sill. Am. J. [2] xvi, 167.
- Phonolite.**—Examination of Phonolite from the Rhön: by *E. Schmidt*. Pogg. Ann. lxxxix, 291.
- Quartz.**—On auriferous Quartz: by *A. B. Northcote*. Phil. Mag. [4] vi, 390.
- Realgar.**—Insolubility of native Realgar (As S_2) in carbonate of ammonia: by *C. G. Williams*. Chem. Gaz. 1853, 252.
- Romeine.**—New researches on the composition of Romeine: by *M. Damour*. Ann. Min. [5] iii, 179.
- Sphene.**—On the isomorphism of Sphene and Euclase: by *J. D. Dana*. Sill. Am. J. [2] xvi, 96.
- Spodumene.**—On the composition of North American Spodumene: by *C. Rammelsberg*. Pogg. Ann. lxxxix, 144.
- Tellurium.**—Analysis of Foliated Tellurium: by *P. H. Schönlein*. Ann. Ch. Pharm. lxxxvi, 201.
- Thierschite.**—On Thierschite: by *J. Liebig*. Ann. Ch. Pharm. lxxxvi, 113; Chem. Soc. Qu. J. vi, 112.
- Tin-pyrites.**—On the chemical composition of Tin-pyrites: by *C. Rammelsberg*. Pogg. Ann. lxxxviii, 603.
- Topaz.**—Account of a remarkable fluid cavity in Topaz: by *D. Brewster*. Phil. Mag. [4] v, 235.
- Trachite.**—On a metamorphosis of Icelandic Trachyte, whereby it is converted into quartz: by *Th. Kjerulf*. Ann. Ch. Pharm. lxxv, 257.
- Trona.**—On some supposed crystals of Trona: by *H. J. Brooke*, with an analysis by *A. Dick*. Phil. Mag. [4] v, 373.
- Wernerite.**—On the composition of Wernerite and its products of decomposition: by *Gerhardt v. Rath*. Pogg. Ann. xc, 62, 288.
- Molasses.**—On the increase in weight of molasses casks, which occasionally arises from absorption: by *W. Ferguson*. Chem. Soc. Qu. J. vi, 122.
- Molecular Action.**—Researches in the quantities of heat disengaged in chemical and molecular actions, 3rd, 4th, and 5th parts (conclusion): by *P. A. Favre* and *J. T. Silbermann*. Ann. Ch. Phys. [3] xxxvii, 406.
- Molybdenum.**—On the reduction and electro-chemical application of molybdenum: by *Junot de Bussy*. Compt. rend. xxxvi, 540.
- On the applicability of molybdic acid and the molybdates to dyeing and calico-printing: by *W. H. Kurrer*. Chem. Gaz. 1853, 435; Pharm. J. Trans. xiii, 225.

- Molybdenum.**—On the use of molybdate of ammonia as a test for arsenic in medico-legal inquiries: by *H. Struve*. J. pr. Chem. lviii, 493; J. Pharm. [3] xxiv, 375; Pharm. J. Trans. xiii, 82.
- Note on a red variety of molybdate of lead from Phoenixville, U.S.: by *C. M. Wetherill*. Phil. Mag. [4] vi, 236.
- Mordants.**—Improvements in the manufacture of certain mordants used in preparing woven or textile fabrics for printing, staining, or dyeing: (Higgins' Patent). Chem. Gaz. 1853, 440.

N.

- Narceine.**—On the rotatory power of narceine: by *Boucharlat* and *F. Boudet*. J. Pharm. [3] xxiii, 288.
- Nickel.**—Note on the presence of nickel and cobalt in certain ferruginous waters, and on a process for isolating them: by *O. Henry*. J. Pharm. [3] xxiv, 305.
- Separation of nickel from cobalt. Ann. Ch. Pharm. lxxxvii, 128.
- On the compounds of boracic acid and water with protoxide of nickel: by *H. Rose*. Pogg. Ann. lxxxviii, 361.
- Analysis of a slag obtained in the smelting of nickel at the Dorothea Works, at Dillenburg: by *W. Winter*. Ann. Ch. Pharm. lxxxvii, 221.
- Passive state of nickel and iron: by *J. Nicklès*. Pogg. Ann. xc, 351.
- On the passive state of nickel and cobalt: by *J. Nicklès*. Compt. rend. xxxvii, 284.
- On the separation of manganese from iron and nickel: by *T. Schiel*. Chem. Gaz. 1853, 413.
- On the determination of copper and nickel in quantitative analysis: by *D. Forbes*. Chem. Gaz. 1853, 276.
- Nitrates.**—New test for nitric acid and the nitrates: by *E. W. Davy*. Phil. Mag. [4] v, 330; J. Pharm. [3] xxiv, 206.
- On the preparation of chemically pure nitrates of potash and soda: by *C. Weber*. Pharm. J. Trans. xii, 596.
- On a method of determining the quantity of nitrate of potash contained in gunpowder: by *M. Uebatius*. Chem. Gaz. 1853, 433.
- On the compounds of basic mercurous nitrate with other nitrates: by *G. Städeler*. Ann. Ch. Pharm. lxxxvii, 129.
- Nitric Oxide.**—On a compound of pelargonic acid with nitric oxide: by *L. Chiozza*. Ann. Ch. Pharm. lxxxv, 225; Chem. Gaz. 1853, 123.
- Nitrogen.**—On two new methods for the determination of nitrogen in organic and inorganic compounds: by *Marcell Simpson*. Chem. Soc. Qu. J. vi, 289.
- New method of forming the protoxide of nitrogen: by *J. L. Smith*. Sill. Am. J. [2] xv, 234; Chem. Gaz. 1853, 250.
- On nitric acid as a source of the nitrogen found in plants: by *G. Wilson*. Trans. Roy. Soc. Edinb. xx, 591.
- On the constitution of iodide of nitrogen: by *R. Bunsen*. Ann. Ch. Pharm. lxxxiv, 1; Ann. Ch. Phys. [3] xxxix, 74; *abstr.* Chem. Soc. Qu. J. vi, 90; J. Pharm. [3] xxiii, 393.
- Nitroprussides.**—On some new methods of forming the nitroprussides: by *E. W. Davy*. Phil. Mag. [4] vi, 11.

Nutrition.—Note on the chemical properties of certain proximate principles of wheat, and their effect in the feeding of animals: by *M. Mouries*. *Compt. rend.* xxxvii, 351.

O.

Önanthyl.—On ethers intermediate between the önanthyllic, and the methylic, ethylic, and amylic series; and on the constitution of castor-oil alcohol: by *A. W. Wills*. *Chem. Soc. Qu. J.* vi, 307.

Oils.—On a method of distinguishing the volatile oils of the series C_5H_4 : by *C. G. Williams*. *Phil. Mag.* [4] v, 536; *J. Pharm.* [3] xxiv, 134.

— Researches on fixed oils of vegetable origin: by *M. Lefort*. *J. Pharm.* [3] xxiii, 278, 350.

— On the preparation of medicinal oils and fats: by *M. Lhermite*. *J. Pharm.* [3] xxiv, 349.

— Report, presented to the Société de Pharmacie, on a method proposed by *M. Behrens* for detecting adulteration in oils: by *MM. Guibourt and Reveil*. *J. Pharm.* [3] xxiv, 349.

— On a method of testing edible oils: by *E. Marchand*. *J. Pharm.* [3] xxiv, 267.

— On the analysis of fixed oils by means of sulphuric acid: by *M. Maumené*. *Chem. Gaz.* 1853, 58; *Pharm. J. Trans.* xiii, 187.

— On the fixed vegetable oils of Southern India. *Pharm. J. Trans.* xii, 598.

— New process for recognizing the presence of alcohol in essential oils: by *M. Oberdörfer*. *J. Pharm.* [3] xxiv, 73.

— On essential oil of bitter almonds: by *D. MacLagan*. *Pharm. J. Trans.* xiii, 277.

— Preparation of a drying oil for zinc paint. *Pharm. J. Trans.* xiii, 294.

— Means of detecting turpentine in mineral naphtha and in oil of amber: by *Dr. Bolley*. *Pharm. J. Trans.* xiii, 292.

— On the compounds of certain volatile oils with the alkaline bisulphites: by *C. Bertagnini*. *Ann. Ch. Pharm.* lxxxv, 179, 268; *Chem. Gaz.* 1853, 46.

— Improvements in preparing oils for lubricating and burning (*Hutchison's Patent*). *Pharm. J. Trans.* xii, 551.

— On the disturbing action exerted by certain metallic salts on drying oils, when exposed to air and light: by *Barruel and Jean*. *Compt. Rend.* xxxvi, 577.

— On the action of phosphorus on drying oils, chiefly on linseed-oil: by *L. E. Jonas*. *Arch. Pharm.* [2] lxxx, 139; *J. Pharm.* [3] xxii, 469.

— On the volatile oil of beech-tar: by *C. Fölckel*. *Ann. Ch. Pharm.* lxxxvi, 331.

— Adulteration of oil of cassia with oil of cloves: by *G. Uler*. *Pharm. J. Trans.* xii, 602.

— On oil of camphor: by *Th. Martens*. *J. Pharm.* [3] xxiii, 473.

— On cod-liver oil. *J. Pharm.* [3] xxiii, 426.

— On the constitution of cod-liver oil. *Pharm. J. Trans.* xii, 450.

— Improvements in deodorizing cod-liver oil: by *Sir James Murray*. *Pharm. J. Trans.* xiii, 188.

— On the adulteration of olive-oil: by *J. Mackay*. *Pharm. J. Trans.* xii, 484; also by *Maumené*. *Ibid.* 497.

— Solubility of biniodide of mercury in cod-liver oil. *Pharm. J. Trans.* xiii, 189

- Oils.—On essential oil of coriander. J. Pharm. [3] xxiii, 479; Chem. Gaz. 1853, 16; Pharm. J. Trans. xii, 396.
- On oil of cummin: by *C. Völckel*. Ann. Ch. Pharm. lxxxv, 246.
- On volatile oil of ginger: by *M. Papoušek*. J. Pharm. [3] xxiii, 465; Chem. Gaz. 1853, 12; Pharm. J. Trans. xii, 601.
- On oil of hops: by *R. Wagner*. J. pr. Chem. lviii, 6; Chem. Gaz. 1853, 272.
- Note on the ozonization of the oils of lemons and turpentine: by *C. G. Williams*. Chem. Gaz. 1853, 331.
- On the action of ammoniacal bases upon oil of mustard: by *F. Hinterberger*. Chem. Gaz. 1853, 71.
- On the preparation of oil of morphine: by *M. St. Lager*. J. Pharm. [3] xxiv, 358.
- Note on the rectification of essential oil of Nerolé: by *M. Danney*. J. Pharm. [3] xxiv, 204.
- Physiological action of the essential oil of oranges: by *J. Goubeyre*. Compt. rend. xxxvi, 623.
- On the acids of rape-oil: by *G. Städeler*. Ann. Ch. Pharm. lxxxvii, 133.
- Improvements in bleaching palm-oil (Dixon's Patent). Pharm. J. Trans. xiii, 46.
- Manufacture of resin and of resin-oil. Pharm. J. Trans. xii, 345, 389.
- On the manufacture of oil of roses. Chem. Gaz. 1853, 98.
- Camphor from oil of sassafras. Ann. Ch. Pharm. lxxxvii, 376.
- On essential oil of thyme: by *A. Lallemant*. Compt. rend. xxxvi, 498; J. Pharm. [3] xxiv, 274.
- Action of heat on oil of turpentine: by *M. Berthelot*. Ann. Ch. Phys. [3] xxxix, 5.
- On the oil of *Wurmsame*: by *C. Völckel*. Ann. Ch. Pharm. lxxxvii, 312.
- Olefiant Gas.—On the production of tar from olefiant gas: by *G. Magnus*. Pogg. Ann. xc, 1; Phil. Mag. [4] vi, 420.
- Opium.—On some of the crystalline constituents of opium: by *T. Anderson*. Ann. Ch. Pharm. lxxxvi, 179.
- Organic Analysis.—On the use of gas as fuel in organic analysis: by *A. W. Hofmann*. Chem. Soc. Qu. J. vi, 209.
- Organic Bases.—Contributions to the history of volatile bases: by *A. Planta* and *A. Kekulé*. Ann. Ch. Pharm. lxxxvii, 1.
- Organic Bodies.—On a new series of organic bodies containing metals: by *E. Frankland*. Phil. Trans. 1852, ii, 417; Ann. Ch. Pharm. lxxxv, 329; Phil. Mag. [4] v, 159, 239; *abstr.* J. Pharm. [3] xxiv, 296; Chem. Soc. Qu. J. vi, 57.
- Organic Radicals.—Researches on the oxygen-radicals: by *L. Chiozza*. Ann. Ch. Pharm. lxxxiv, 102; Compt. rend. xxxv, 225; Chem. Soc. Qu. J. vi, 182.
- Researches on stanmethy, a new organic radical: by *A. Cahours* and *A. Riche*. Compt. Rend. xxxvi, 1001.
- Othyl.—Remarks on Professor Williamson's othyl-theory: by *F. Wrightson*. Phil. Mag. [4] vi, 418.
- Oxides.—Note on the separation of some metallic oxides: by *M. Flajolot*. Compt. rend. xxxvi, 1090; Chem. Gaz. 1853, 379; Ann. Min. [5] 652.

Oxides.—On the behaviour of certain oxides with caustic potash in the presence of oxide of chromium: by *A. B. Northcote* and *A. H. Church*. Chem. Soc. Qu. J. vi, 54.

Oxygen.—On the electro-chemical department of oxygen: by *M. Viard*. Phil. Mag. [4] vi, 241.

— On the function of oxygen in the life of plants and the action of manure: by *E. Robin*. Rev. Sci. xlii, 407.

Ozone.—On a new oxide of hydrogen and its relation to ozone: by *M. Baumert*. Pogg. Ann. lxxxix, 37; Phil. Mag. [4] vi, 51; Chem. Soc. Qu. J. vi, 169.

— Note on the ozonization of the oils of lemons and turpentine: by *C. G. Williams*. Chem. Gaz. 1853, 331.

P.

Palladium.—Facts relating to the analytical history of palladium and silver: by *A. Béchamp*. J. Pharm. [3] xxiii, 413.

— On palladamine: by *Hugo Müller*. Ann. Ch. Pharm. lxxxvi, 341.

Papaverine.—On the rotatory power of papaverine: by *Boucharlat* and *F. Boudet*. J. Pharm. [3] xxiii, 288.

Papier-maché.—Substitute for papier-maché (Warren's Patent). Chem. Gaz. 1853, 439.

Pelargonates.—On the preparation of crude pelargonate of ethyl: by *R. Wagner*. Chem. Gaz. 1853, 144.

Phosphate.—On the composition of phosphate of mercury: by *R. Brandes*. J. Pharm. [3] xxiv, 80.

Phosphates.—Action of caustic potash on the phosphates: by *A. B. Northcote* and *A. H. Church*. Chem. Soc. Qu. J. vi, 53.

Phosphides.—On phosphide of manganese. Ann. Ch. Pharm. lxxxvi, 371.

— On phosphide of titanium: by *Wöhler*. Ann. Ch. Pharm. lxxxvii, 376.

Phosphorescence.—On the phosphorescence of some marine invertebrata: by *A. de Quatrefages*. Sill. Am. J. [2] xvi, 69.

Phosphorus.—On the specific heat of red phosphorus: by *V. Regnault*. Pogg. Ann. lxxxix, 49; Ann. Ch. Phys. [3] xxxviii, 129.

— On the discovery of phosphorus: by *J. Ince*. Pharm. J. Trans. xiii, 280.

— On the so-called amorphous phosphorus: by *A. Puttfarcken*. Ann. Ch. Pharm. lxxv, 136; Chem. Gaz. 1853, 447.

— Action of phosphorus, sulphur, arsenic, and antimony upon certain classes of salts: by *J. W. Slater*. Chem. Gaz. 1853, 329.

— On the crystallization of sulphur and phosphorus. Compt. rend. xxxvi, 463.

— Action of phosphorus on drying oils, chiefly on linseed-oil: by *L. E. Jonas*. Arch. Pharm. [2] lxx, 139; J. Pharm. [3] xxii, 469.

— On hypochlorite of magnesia as an antidote to phosphorus: by *M. Bechert*. J. Pharm. [3] xxiv, 352; Pharm. J. Trans. xii, 603.

— Observations on sulphide of phosphorus: by *W. Wicke*. Ann. Ch. Pharm. lxxxvi, 115.

— Note on the oxide of phosphorus: by *A. Schrötter*. Ann. Ch. Phys. [3] xxxviii, 148.

- Photography.—Method of obtaining direct positive photographic impressions on plates of any kind whatever, especially on those which serve for engraving: by *A. Martin*. Compt. rend. xxxvi, 703.
- New method of obtaining positive impressions, of any dimensions and of equal delicacy with the negative: by *M. Heilmann*. Compt. rend. xxxvii, 136.
- On the best mode of focussing the photographic apparatus: by *A. Claudet*. J. Fr. Inst. [3] xxvi, 201.
- On certain causes of failure in photographic operations and on the precautions to be taken to avoid them: by *M. Bertsch*. Compt. rend. xxxvii, 135.
- On the cause of the occurrence of abnormal figures in photographic impressions of polarized rings: by *G. G. Stokes*. Phil. Mag. [4] vi, 107.
- Fixation of colours. J. Fr. Inst. [] xxv, 141.
- Process for taking photographic landscapes on paper: by *J. Stewart*. J. Fr. Inst. [3] xxv, 402.
- On the application of photography to the study of certain phenomena of polarization: by *W. Crookes*. Phil. Mag. [4] vi, 73.
- Photographic engraving on steel: by *H. F. Talbot*. Compt. rend. xxxvi, 780; also by *M. Niepce de St. Victor*. Ibid. 908. Remarks on the latter: by *M. Chevreul*. Ibid. 908. Remarks on both memoirs: by *M. Biot*. Ibid. 801.
- Process for photographic engraving: by *H. F. Talbot*. J. Fr. Inst. [3] xxvi, 121.
- Application of the microscope to photography: by *W. T. Kingsley*. J. Fr. Inst. [3] xxvi, 188.
- Photography on stone: by *MM. Barreswil and Lemercier*. Chem. Gaz. 1853, 275.
- Phycite.—On phycite, the saccharine matter of *Protococcus vulgaris*: by *M. Lamy*. Compt. rend. xxxv, 665. Chem. Gaz. 1853, 200.
- Physeline.—On physaline: by *V. Dessaignes* and *J. Chantard*. Chem. Gaz. 1853, 15.
- Physical Properties.—Observations on certain physical properties of bodies: by *J. Groshans*. Pogg. Ann. Ergänzungsband, iii, 4, 596; further, lxxxviii, 291.
- Physiological Chemistry.—On the causes of old age and of death in advanced life: by *E. Robin*. Compt. rend. xxxvi, 147.
- Picrotoxine.—On the rotatory power of picrotoxine: by *Bouchardat* and *F. Boudet*. J. Pharm. [3] xxiii, 288.
- Piperine.—Researches on a new alkali derived from piperine: by *A. Cahours*. Ann. Ch. Phys. [3] xxxviii, 38; abstr. Chem. Soc. Qu. J. vi, 175.
- Plants.—On the absorption of inorganic salts by plants: by *Schulz-Fleeth*. Pogg. Ann. lxxxviii, 177.
- On the existence of iodine in various plants: by *Stevenson Macadam*. J. Pharm. [3] xxiii, 294; Chem. Soc. Qu. J. vi, 168.
- Platinum.—On the equivalent weights of platinum and barium: by *T. Andrews*. Ann. Ch. Pharm, lxxxv, 255.
- On a probably new element associated with iridosmine and platinum: by *A. F. Genth*. Sill. Am. J. [2] xv, 246; Chem. Gaz. 1853, 145.

- Poisons.**—On the use of *aqua-regia* in testing for poisons: by *Gaultier de Claubry*. J. Pharm. [3] xxiii, 209. Remarks on the same: by *Malaguti* and *Sarzeaud*. Ibid. 296.
- New mode of analysis for detecting organic poisons: by *C. Flandin*. Compt. rend. xxxvi, 517; Pharm. J. Trans. xiii, 39.
- Nature of some of the approved processes for the detection of poisons: by *D. MacLagan*. Pharm. J. Trans. xii, 379.
- Polarized Light.**—New researches on the relations which may exist between crystalline form, chemical composition and rotatory power: by *L. Pasteur*. Ann. Ch. Phys. [3] xxxviii, 437.
- Report on a memoir by M. Pasteur, entitled "New researches on the relations which may exist between crystalline form, chemical composition and rotatory power": by *H. de Senarmont*. Compt. rend. xxxvi, 757.
- On the action of magnetism on a rectilineally polarized ray in its passage through compressed glass: by *Prof. Edbrund*. Ann. Ch. Pharm. lxxxvii, 338.
- Detection of small quantities of soda by means of polarized light: by *Th. Andrews*. Pogg. Ann. lxxxviii, 171.
- Note on the rotatory powers of quinidine, codeine, narceine, papaverine, and picrotoxine: by *Bouchardat* and *F. Boudet*. J. Pharm. [3] xxiii, 288.
- Polymorphism.**—Researches on polymorphism: by *J. Nicklès*. J. Pharm. [3] xxiii, 417; xxiv, 5.
- Poppy.**—Researches on the composition and medicinal properties of the different kinds of white poppy: by *M. Meurien*. J. Pharm. [3] xxiii, 176, 262, 332.
- Porcelain**—American porcelain. J. Fr. Inst. [3] xxv, 43.
- Porphyry.**—On the composition of quartz-porphyry: by *Dr. v. Tribolet*. Ann. Ch. Pharm. lxxxvii, 327.
- Potash.**—Preparation of pure hydrate of potash: by *Wöhler*. Ann. Ch. Pharm. lxxxvii, 373.
- On the preparation of carbonate of potash: by *C. Weber*. Pharm. J. Trans. xiii, 43.
- On the behaviour of certain oxides with caustic potash in presence of oxide of chromium: by *A. B. Northcote* and *A. H. Church*. Chem. Soc. Qu. J. vi, 54.
- Action of caustic potash on the phosphates: by *A. B. Northcote* and *A. H. Church*. Chem. Soc. Qu. J. vi, 53.
- On a compound sulphate of potash and soda: by *J. H. Gladstone*. Chem. Soc. Qu. J. vi, 106.
- Potassium.**—Detection of potassium in meteoric iron: by *C. U. Shepard*. Sill. Am. J. [2] xv, 1.
- On a new concrete sulphide of potassium: by *M. Goble*. J. Pharm. [3] xxiii, 350.
- Potato.**—Remarks on the potato disease: by *T. J. Herapath*. Chem. Gaz. 1853, 362, 382.
- Propyl.**—On propionic alcohol: by *G. Chance*. Compt. rend. xxxvii, 410; Chem. Soc. Qu. J. vi, 287.

- Protean Stone.—On protean stone, or artificial ivory. *J. Pharm.* [3] xxii, 444.
- Prussiates.—On the mode of estimating the value of red prussiate of potash: by *F. Lieshing*. *Chem. Soc. Qu. J.* vi, 31; *Chem. Gaz.* 1853, 139.
- Pseudomorphoses.—On pseudomorphoses, with observations on the mode of distinguishing certain kinds of them: by *T. Scheerer*. *Pogg. Ann.* lxxxix, 1; xc, 315.
- Purpurin.—On oxylicaric acid (purpurin): by *H. Debus*. *Ann. Ch. Pharm.* lxxxvi, 117.
- Pyrophosphates.—Syrup of pyrophosphate of iron: by *M. Soubeiran*. *J. Pharm.* [3] xxiii, 62.
- Pyrotartrates.—On pyrotartrate of ammonia, and its transformation by heat: by *A. E. Arppe*. *Ann. Ch. Pharm.* lxxxvii, 237.
- Pyroxyline.—Researches on pyroxyline: by *A. Béchamp*. *Ann. Ch. Phys.* [3] xxxvii, 206; *J. Pharm.* [3] xxii, 410.
- Action of protosalts of iron on pyroxylin and its congeners: by *A. Béchamp*. *Compt. rend.* xxxvii, 134.
- Pressure.—Influence of pressure on the permanence of compounds. *Ann. Ch. Pharm.* lxxxv, 374.

Q.

- Quinidine.—Note on quinidine: by *L. Pasteur*. *Compt. rend.* xxxvi, 26; *Chem. Gaz.* 1853, 123; *J. Pharm.* [3] xxiii, 123.
- Observations on quinidine: by *MM. Bussy and Guibourt*. *J. Pharm.* [3] xxii, 401.
- On the rotatory power of quinidine: by *Bouchardat* and *F. Boudet*. *J. Pharm.* [3] xxiii, 288.
- Quinine.—On the manufacture of large available crystals of sulphate of iodoquinine (Herapathite) for optical purposes, as artificial tourmalines: by *W. B. Herapath*. *Phil. Mag.* [4] vi, 346.
- Action of carbonic acid on quinine and cinchonine; formation of crystallized carbonate of quinine: by *M. Langlois*. *Compt. rend.* xxxvii, 727.
- On the *iodo-quinine* examined by Dr. Herapath and Prof. Stokes in its optical relations: by *W. Haidinger*. *Pogg. Ann.* lxxxix, 250; *Phil. Mag.* [4] vi, 273.
- Sulphate of quinine. *Pharm. J. Trans.* xiii, 209.
- On the discovery of quinine and quinidine in the urine of patients under medical treatment with the salts of these mixed alkaloids: by *W. B. Herapath*. *Phil. Mag.* [4] vi, 171; *Pharm. J. Trans.* xiii, 216.
- On the adulteration of the citrate of iron and quinine of commerce: by *C. G. Williams*. *Chem. Gaz.* 1853, 269.
- On the red colouring of quinine by ferrocyanide of potassium: by *A. Vogel*. *Ann. Ch. Pharm.* lxxxvi, 122.
- Pharmacological researches on tannate of quinine. *J. Pharm.* [3] xxiii, 158.

R.

- Resin.—Manufacture of resin and of resin-oil. Pharm. J. Trans. xii, 345, 389.
- On a new fossil resin: by *J. W. Mallet*. Ann. Ch. Pharm. lxxxv, 135.
- On the resin of jalap: by *W. Mayer*. Chem. Gaz. 1853, 21.
- Rhamnus.—On rhamnoxanthene, a new yellow colouring-matter, extracted from the root-bark of *Rhamnus frangula*: by *L. A. Buchner*. J. Pharm. [3] xxiv, 50, 293.
- Rhododendron.—Examination of the leaves of *Rhododendron ferrugineum*: by *R. Schwartz*. Chem. Gaz. 1853, 44.
- Rocks.—Researches on the formation of volcanic rocks in Iceland: by *R. Bunsen*. Ann. Ch. Phys. [3] xxxviii, 215.
- On the structure and composition of certain basaltic and metamorphic rocks: by *T. Andrews*. Ann. Ch. Pharm. lxxxv, 172; Pogg. Ann. lxxxviii, 321.
- Researches on the products of the decomposition of rocks by hot sulphurous waters: by *M. Bouis*. Compt. rend. xxxvii, 234.
- On the theory of the formation of volcanic rocks: by *H. Streng*. Ann. Ch. Phys. xxxix, 52; Pogg. Ann. xc, 103.
- On the mineralogical and chemical composition of the rocks of the Vosges: by *M. Delesse*. Ann. Min. [5] iii, 369, 747.
- Rotten-stone.—On the origin and composition of rotten-stone: by *Prof. Johnston*. Chem. Gaz. 1853, 418; Pharm. J. Trans. xiii, 222.
- Rubian.—On rubian and its products of decomposition: by *E. Schunk*. Phil. Mag. [4] v, 410, 495; Ann. Ch. Pharm. lxxxvii, 344.

S.

- Saccharometer.—On Soleil's saccharometer: by *W. P. Riddell*. Sill. Am. J. [2] xv, 175.
- Sal-ammoniac.—A method of getting rid of sal-ammoniac in analysis: by *J. L. Smith*. Sill. Am. J. [2] xv, 94; Chem. Gaz. 1854, 115.
- Salicyl.—On the formation of hydride of salicyl in the flowers of meadow-sweet (*Spiraea ulmaria*): by *L. A. Buchner*. J. Pharm. [3] xxiv, 73.
- Saline Solutions.—Observations on the supersaturation of saline solutions: by *H. Löwell*. Ann. Ch. Phys. [3] xxxvii, 155, 179.
- Saliva.—On the quantitative determination of the sulphocyanide of potassium in saliva: by *T. J. Herapath*. Chem. Gaz. 1853, 294.
- Salt.—Note on the probable existence of saliferous strata in the north of France: by *M. Delanoue*. Compt. rend. xxxv, 850.
- Examination of the *Orber Badesalz*: by *Freiherr v. Bibra*. Ann. Ch. Pharm. lxxxvii, 179.
- Salt of Western Pennsylvania: by *J. C. Booth* and *T. H. Garrett*. J. Frank. Inst. [3] xxv, 48.
- Saltpetre.—Remarks on the artificial productions of saltpetre: by *R. Reichenbach*. Pharm. J. Trans. xiii, 136.

- Saltpetre.—Exposition of certain facts relating to the reciprocal action of soluble salt : by *J. Malaguti*. Ann. Ch. Phys. [3] xxxvii, 198 ; Compt. rend. xxxv, 945.
- On the relation between the constitution of salts and the quantity of water contained in them : by *P. Kremers*. Pogg. Ann. lxxxviii, 337.
- On the absorption of inorganic salts by plants : by *Schulz-Fleeth*. Pogg. Ann. lxxxviii, 177.
- Action of phosphorus, sulphur, arsenic and antimony upon certain classes of salts : by *J. W. Draper*. Chem. Gaz. 1853, 329.
- Improvements in the manufacture of certain salts of potash, soda, ammonia, lime, and baryta (Price's Patent). Pharm. J. Trans. xiii, 46.
- Improvements in saline and metallic compounds (Claussen's Patent). Chem. Gaz. 1853, 20.
- Sarsaparilla.—On a species of smilax, and a new sort of sarsaparilla obtained from it : by *R. Bentley*. Pharm. J. Trans. xii, 470.
- On Guatemala sarsaparilla : by *R. Bentley*. J. Pharm. [3] xxiv, 45.
- Scammony.—On virgin-scammony and on the characters of scammony-resin : by *W. Ball*. J. Pharm. [3] xxii, 446.
- Production of scammony in the neighbourhood of Smyrna : by *H. Maltass*. Pharm. J. Trans. xiii, 264.
- Note on some specimens of scammony : by *D. Hanbury*. Pharm. J. Trans. xiii, 268.
- Scilla.—Memoir on scilla : by *M. Tilloy*. J. Pharm. [3] xxiii, 406.
- Selenium.—On the specific gravity of selenium : by *F. G. Schaffgotsch*. Pogg. Ann. xc, 66.
- On the compounds of the two acids of selenium with the two oxides of mercury, and on native mercurous selenite (Onofrite) : by *F. Köhler*. Pogg. Ann. lxxxix, 146.
- On selenide of mercury from the Hartz : by *C. Rammelsberg*. Pogg. Ann. lxxxviii, 319 ; Phil. Mag. [4] vi, 272.
- On selenide of ethyl : by *C. A. Joy*. Ann. Ch. Pharm. lxxxvi, 35.
- Seminaphthalidine.—On azobenzide, azoxybenzide, and seminaphthalidine according to *N. Zinin*. Ann. Ch. Pharm. lxxxv, 328.
- Silica.—On the quantitative determination of the alkalis in siliceous minerals not soluble in acids : by *J. L. Smith*. Sill. Am. J. [2] xv, 94 ; Chem. Gaz. 1853, 252.
- On deposits of soluble or gelatinous silica in the lower beds of the chalk formation : by *J. T. Way*. Chem. Soc. Qu. J. vi, 102 ; Pharm. J. Trans. xiii, 174.
- Analysis of a siliceous deposit from the hot volcanic springs of Taupo, New Zealand : by *J. W. Mallet*. Phil. Mag. [4] v, 285.
- Silicium.—On the reduction and electro-chemical application of silicium : by *Juno de Bussy*. Compt. rend. xxxvi, 540.
- Silk.—On the detection of silk, wool, linen and cotton fibres and textile fabrics : by *G. C. Wittstein*. Pharm. J. Trans. xiii, 181.
- Silver.—On silver as a unit of measure for resistance to electric conduction : by *W. Langsdorf*. Ann. Ch. Pharm. lxxxv, 155.
- Facts relating to the analytical history of palladium and silver : by *A. Béchamp*. J. Pharm. [3] xxiii, 413.

Silver.—On the compounds of boracic acid and water with oxide of silver: by *H. Rose*. Pogg. Ann. lxxxviii, 482.

— Hard silver. Pogg. Ann. lxxxviii, 176.

— On the mutual action between the two ferrocyanides of potassium, and the nitrate and the simple combustion-products of silver: by *O. B. Kühn*. Ann. Ch. Pharm. lxxxvii, 84.

— On the reactions on which the amalgamation process depends, and on the extraction of silver by amalgamation: by *Dr. Karsten*. Chem. Gaz. 1853, 141.

— On the desilverizing of argentiferous lead by means of zinc: by *Dr. Karsten*. Chem. Gaz. 1853, 132.

— Note on a new alloy of silver: by *G. Barruel*. Chem. Gaz. 1852, 15.

— On the recovery of gold and silver from the liquids employed in electroplating and gilding: by *P. Bolley*. Chem. Gaz. 1853, 354.

Sinapine.—Researches on sinapine: by *L. v. Babo* and *M. Hirschbrunn*. Chem. Gaz. 1853, 81; Chem. Soc. Qu. J. vi, 187; J. Pharm. [3] xxiii, 394; Ann. Ch. Phys. [3] xxxviii, 104.

Soap.—On soaps and their employment in manufactures: by *F. C. Culvert*. Chem. Gaz. 1853, 115.

— Process for determining the value of soap: by *Dr. Bolley*. Chem. Gaz. 1853, 55.

Soda.—Detection of small quantities of soda by means of polarized light: by *Th. Andrews*. Pogg. Ann. lxxxviii, 171.

— On the action of soda on the sulphuric compounds of indigo: by *C. Gros-Renaud, Jun.* Bull. de la Soc. Industr. de Mulhouse, xxiv, 343.

— Improvements in the manufacture of carbonates of soda (*W. E. Newton's* Patent). Chem. Gaz. 1853, 359.

— On the presence of soda in commercial potash: by *C. G. Williams*. J. Pharm. [3] xxiv, 290.

— On a compound sulphate of potash and soda: by *J. H. Gladstone*, Chem. Soc. Qu. J. vi, 106.

— Notice of a native carbonate of soda found in the territory of Nizam, India: by *W. H. Bradley*. Pharm. J. Trans. xii, 515.

Soils.—Analysis of the ashes of *Erica carnea* and *Culluna vulgaris* *Salisb.*, and of the soils on which they grow: by *C. F. Röhle*. Ann. Ch. Pharm. lxxxvii, 118.

— Report on a memoir by *MM. Verdeil and Rissler*, entitled: "Researches on the composition of the soluble matters extracted by water from fertile soils": by *M. de Gasparin*. Compt. rend. xxxvi, 765.

Spermaceti.—On the composition of mutton-fat, human fat, and spermaceti (Addendum): by *W. Heintz*. Pogg. Ann. lxxxvii, 553.

— Means of powdering spermaceti. Pharm. J. Trans. xii, 550.

Stalactites.—Note on the consolidation of stalactites and of calcareous strata: by *M. Fournet*. Compt. rend. xxxvi, 987.

Stannethyl.—Researches on the stannethyls, a new series of organic radicals formed of ethyl and tin: by *C. Löwig*. Ann. Ch. Phys. [3] xxxvii, 343; *abstr.* J. Pharm. [3] xxiii, 234; Chem. Gaz. 1853, 101, 126, 149, 170.

- Stearin.—On the manufacture of stearin candles: by *MM. Lamasse and Co.* Bull. de la Soc. Industr. de Mulhouse, xxiii, 314.—Report thereupon: by *Dr Penot.* Ibid. 317.
- Steel.—On the manufacture of cast steel: by *Dr. Karsten.* Chem. Gaz. 1853, 233.
- Strychnine.—New method of detecting strychnine and its salts: by *W. Davy.* J. Pharm. [3] xxiv, 204.
- On the effects of acetate of strychnine (2nd memoir). Compt. rend. xxxvi, 289.
- Suet.—On the composition of beef-suet: by *W. Heintz.* Pogg. Ann. lxxxix, 579.
- Sugar.—On the processes connected with the manufacture of sugar from beet-molasses. Pharm. J. Trans. xiii, 229.
- Improvements in refining sugar (Bessemer's Patent). Pharm. J. Trans. xii, 453.
- Improvements in the manufacture of raw and refined sugar (Brandris' Patent). Pharm. J. Trans. xii, 355.
- Improvements in the manufacture of sugar (Egan's Patent). Pharm. J. Trans. xii, 453.
- On *MM. Leplay and Dubranfaut's* improvements in the manufacture of sugar: by *J. Nicklès.* Chem. Gaz. 1853, 387.
- Action of alkalis on sugar. Pharm. J. Trans. xii, 348, 393.
- On the occurrence of aldehyde among the products of the distillation of sugar: by *C. Völckel.* Ann. Ch. Pharm. lxxxvii, 303.
- On the gases formed in the distillation of sugar: by *C. Völckel.* Ann. Ch. Pharm. lxxxvi, 63.
- Action exerted by acids and by alkaline and earthy chlorides on sugar: by *M. Berthelot.* Ann. Ch. Phys. [3] xxxviii, 38.
- On the seat of the sugar formation in the animal body: by *J. Moleschott.* Chem. Gaz. 1853, 381.
- Note on the estimation of sugar of milk, and on the means of detecting adulterations in milk: by *M. Poggiale.* Compt. rend. xxxvi, 265.
- Note on the presence of sugar in the urine of epileptic patients: by *Michea and Reynoso.* Compt. rend. xxxvi, 230.
- Sulphamylates.—Action of ammonia on sulphamylate of lime: by *M. Berthelot.* Ann. Ch. Pharm. lxxxvii, 364; Compt. rend. xxxvi, 1098.
- Sulphates.—Process for making sulphate of soda. Pharm. J. Trans. xii, 601.
- On a compound sulphate of potash and soda: by *J. H. Gladstone.* Chem. Soc. Qu. J. vi, 102; J. Pharm. [3] xxi, 1205.
- On the preparation of chemically pure sulphate of magnesia: by *C. Weber.* Pharm. J. Trans. xii, 59, 76.
- On the effect of sulphate of lime on vegetable substances: by *M. Clausen.* Chem. Gaz. 1853, 437.
- Sulphides.—Researches on sulphides decomposable by water, followed by general considerations on the production of sulphurous and siliceous waters: by *M. Fremy.* Compt. rend. xxxvi, 178; J. Pharm. [3] xxiii, 161; Ann. Ch. Phys. [3] xxxviii, 312.
- On the sulphide of antimony: by *Wackenroder.* Arch. Pharm. [2] lxxi, 207; J. Pharm. [3] xxiii, 156.

Sulphides.—On the compounds of the sulphides of ethyl and methyl with certain metallic chlorides: by *A. Lori*. *J. Pharm.* [3] xxiv, 251; *Ann. Ch. Pharm.* lxxvii, 369; *Chem. Gaz.* 1853, 361; *Compt. rend.* xxxxi, 1095.

— On a new concrete sulphide of potassium: by *M. Goble*. *J. Pharm.* [3] xxiii, 350.

Sulphites.—On several new sulphites of mercuric oxide and cuprous oxide: by *L. Péan de St. Gilles*. *J. Pharm.* [3] xxiii, 45; *Compt. rend.* xxxvi, 1086.—Remarks thereupon: by *M. Chevreul*. *Ibid.* 1089.

— On the compounds of certain volatile oils with the alkaline bisulphites: by *C. Bertagnini*. *Ann. Ch. Pharm.* lxxxv, 179, 268; *Chem. Gaz.* 1853, 46.

Sulphopurpurates.—On the introduction of sulphopurpurate of soda (*carmin d'indigo rouge*) into wool and silk-dyeing: by *E. Haefely*. *Bull. de la Soc. Industr. de Mulhouse*, xxiv, 321.—Report thereupon: by *C. Koechlin*. *Ibid.* 328.

Sulphur.—On the amorphism and polymorphism of sulphur: by *C. Brame*. *Compt. rend.* xxxvii, 334.

— On compact transparent sulphur and vitreous arsenious acid: by *C. Brame*. *Ann. Ch. Phys.* [3] xxxvii, 217.

— On the heat evolved when crystals of sulphur, obtained by fusion, pass into the other form: by *E. Mitscherlich*. *Pogg. Ann.* lxxxviii, 328.

— On the crystallization of sulphur. *Compt. rend.* xxxvi, 463.

— On the isomeric compounds of sulphur and antimony: by *H. Rose*. *Ber. d. Akad. d. Wiss. zu Berlin*, 1853, 242; *Chem. Gaz.* 1853, 290.

— Action of sulphur on certain classes of salts: by *J. W. Slater*. *Chem. Gaz.* 1853, 329.

— On the purification of iron and coke from sulphur. *J. Fr. Inst.* [3] xxv, 47.

— Blue sulphur? *Ann. Ch. Pharm.* lxxxvi, 373.

— On the detection of sulphide of carbon: by *A. Vogel*. *Ann. Ch. Pharm.* lxxxvi, 371.

— Observations on sulphides of phosphorus: by *W. Wicke*. *Ann. Ch. Pharm.* lxxxvi, 115.

— On crystallized sulphur of utricular origin, from Guadaloupe and Vulcano: by *M. Brame*. *Compt. rend.* xxxvii, 784.

Sulphuretted Hydrogen.—Apparatus for disengaging sulphuretted hydrogen: by *R. Fresenius*. *Pharm. J. Trans.* xiii, 131.

Syrups.—On syrup of violets: by *F. Kendall*. *Pharm. J. Trans.* xiii, 18.

— On syrup of iodide of iron and manganese: by *W. Proctor*. *Pharm. J. Trans.* xiii, 88.

T.

Tallow.—Purification of tallow and grease. *Pharm. J. Trans.* xii, 518.

Tanques.—Researches on the *tanques* of Lower Normandy: by *J. I. Pierre*. *Ann. Ch. Phys.* [3] xxxvii, 81.

Tannates.—Pharmacological researches on tannate of quinine. *J. Pharm.* [3] xxiii, 158.

- Tar.—On the production of tar from olefiant gas: by *G. Magnus*. Pogg. Ann. xc, 1; Phil. Mag. [4] vi, 420.
- Improvements in the distillation of tar (Shand and M'Clean's Patent). Pharm. J. Trans. xiii, 46.
- Tea.—On the adulteration of tea. J. Pharm. [3] xxiv, 228.
- Tellurium.—On the action of tellurium on the animal economy: by *K. Hansen*. Ann. Ch. Pharm. lxxxvi, 208.
- Analysis of foliated tellurium: by *Ph. Schönlein*. Ann. Ch. Pharm. lxxxvi, 201.
- On some new compounds of tellurethyl: by *Prof. Wöhler*. Chem. Soc. Qu. J. vi, 40; Chem. Gaz. 1853, 49.
- Teturethylammonium.—On a decomposition-product of teturethylammonium: by *Prof. Weltzien*. Ann. Ch. Pharm. lxxxvi, 292.
- Thalia.—On the supposed new element Thalia: by *J. L. Smith*. Sill. Am. J. [2] xvi, 95; Chem. Gaz. 1853, 353.
- Thermo-chemistry.—Fundamental principles of a system of thermo-chemistry: by *J. Thomson*. Pogg. Ann. xc, 261.
- Thermo-chemical researches on combinations formed in multiple proportions: by *P. A. Favre*. J. Pharm. [3] xxiv, 311.
- Thermometer.—On the absolute zero of the perfect gas-thermometer; being a note to a paper on the mechanical action of heat: by *W. J. M. Rankine*. Trans. Roy. Soc. Edinb. xx, 561; *abstr.* Proc. Roy. Soc. Edinb. 1852-53, 160.
- Thierschite.—Note on Thierschite: by *J. Liebig*. Chem. Soc. Qu. J. vi, 112; Ann. Ph. Pharm. lxxxvi, 113; Ann. Ch. Phys. [3] xxxxiii, 490.
- Thorina.—Additional observations on the thorina (oxide of donarium) obtained from Orangite: by *N. J. Berlin*. Pogg. Ann. lxxxvii, 608.
- Tin.—Improvements in the manufacture of tin (Michell's Patent). Pharm. J. Trans. xii, 550.
- Estimation of tin by means of graduated solutions: by *M. St. Léger*. J. Pharm. [3] xxiv, 20.
- On Tinstone Pseudomorphs: by *E. J. Chapman*. Phil. Mag. [4] vi, 121.
- On the chemical compounds of copper and tin, and on mixtures of these metals constituting non-chemical alloys: by *M. Rieffel*. Compt. rend. xxxvii, 450.
- On the chemical composition of tin-pyrites: by *C. Rammelsberg*. Pogg. Ann. lxxxviii, 603.
- Protiodide of tin. Ann. Ch. Pharm. lxxxvi, 374.
- Researches on stannethyl: by *A. Cahours* and *A. Riche*. Compt. rend. xxxvi, 1001.
- Researches on the stannethyls, a series of new organic radicals formed of ethyl and tin: by *C. Löwig*. Ann. Ch. Phys. [3] xxxvii, 343; J. Pharm. [3] xxiii, 234; Chem. Gaz. 1853, 101, 126, 149, 170.
- Titanium.—On the reduction and electro-chemical application of titanium: by *Junot de Bussy*. Compt. rend. xxxvi, 540.
- On phosphide of titanium: by *Wöhler*. Ann. Ch. Pharm. lxxxvii, 375.
- Toluidine.—On a new mode of formation of toluidine: by *M. Chautard*. J. Pharm. [3] xxiv, 166.
- Toxicology.—On the toxicology of bichromate of potash: by *M. Jaillard*. J. Pharm. [3] xxiv, 38.

- Trochus.**—Analysis of the operculum of a trochus: by *W. Wicke*. *Ann. Ch. Pharm.* lxxxvii, 225.
- Tungsten.**—On the reduction and electro-chemical application of tungsten: by *Juvot de Bussy*. *Compt. rend.* xxxvi, 540.
- On tungstate of lead or Scheele's tincture: by *E. J. Chapman*. *Phil. Mag.* [4] vi, 120.
- Turpentine.**—On the various kind of oils of turpentine: by *M. Berthelot*. *Compt. rend.* xxxvi, 425.
- Action of heat on oil of turpentine: by *M. Berthelot*. *Ann. Ch. Phys.* [3] xxxix, 22.
- Action of acids and of alkaline and earthy chlorides on oil of turpentine: by *M. Berthelot*. *Ann. Ch. Phys.* [3] xxxviii, 38.
- On a product of the action of sulphuric acid on resinized oil of turpentine: by *F. Kuberth*. *Chem. Gaz.* 1853, 385.
- On bihydrochlorate of oil of turpentine: by *M. Berthelot*. *Ann. Ch. Phys.* [3] xxxvii, 223.
- Tyrosin.**—Test for leucin and tyrosin: by *Reinhold Hoffmann*. *Ann. Ch. Pharm.* lxxxvii, 123.

U.

- Ultramarine.**—On commercial ultramarines: by *M. Barreswil*. *J. Pharm.* [3] xxii, 443.
- Test of the purity of ultramarine. *Pharm. J. Trans.* xiii, 40.
- Urea.**—On some compounds of urea, and on a new method for the determination of chloride of sodium and of urea in urine: by *J. Liebig*. *Ann. Ch. Pharm.* lxxxv, 289; *Chem. Soc. Qu. J.* vi, 1; *Ann. Ch. Phys.* [3] xxxix, 86; *J. Pharm.* [3] xxiv, 299.
- Experiments on the production of urea: by *Prof. Bischoff*. *Compt. rend.* xxxvi, 875; *Chem. Gaz.* 1853, 289.
- On a new method for the determination of urea: by *J. W. Draper*. *Phil. Mag.* [3] vi, 290.
- Urine.**—Note on the presence of sugar in the urine of epileptic patients: by *Michea and Reynoso*. *Compt. rend.* xxxvi, 230.
- On the discovery of quinine and quinidine in the urine of patients under medical treatment with the salts of these mixed alkaloids: by *W. B. Herapath*. *Phil. Mag.* [4] vi, 171.
- On the frequent occurrence of indigo in human urine, and on its chemical and physiological relations: by *A. H. Hassall*. *Chem. Gaz.* 1853, 355.
- On the solution of urinary calculi in dilute saline fluids at the temperature of the body by the aid of electricity: by *H. Bence Jones*. *Chem. Gaz.* 1853, 99.

V.

- Vacuum.**—On a method of obtaining a perfect vacuum under the receiver of an air-pump: by *T. Andrews*. *Pogg. Ann.* lxxxviii, 309.
- Vanadium.**—On an iron-ore containing vanadium. *Ann. Ch. Pharm.* lxxxvi, 127.

- Vapours.—On the use of hydrogen in determining vapour-densities: by *R. Raillon*. Chem. Soc. Qu. J. vi, 205.
- Varnishes.—Composition for varnishing iron and steel and protecting them from oxidation. Rev. Sci. xlii, 405.
- Tinctures and varnishes for the wood-work of fire-arms. Rev. Sci. xlii, 385.
- Vegetable Substances.—On the effect of sulphate of lime upon vegetable substances: by *M. Claussen*. Chem. Gaz. 1853, 437.
- Vegetation.—Experimental researches on vegetation: by *M. Ville*. Pharm. J. Trans. xii, 489.
- Vetch.—Analysis of the ashes of vetch-seed from Neufchatel: by *J. Cohen*. Ann. Ch. Pharm. lxxxv, 288.
- Vinegar.—Pyrogallic acid in wood-vinegar. Ann. Ch. Pharm. lxxxvii, 256.
- Volcanic Phenomena.—Researches on the intrinsic relations of the pseudo-volcanic phenomena of Iceland: by *R. Bunsen*. Ann. Ch. Phys. [3] xxxviii, 385.
- Volcanic Rocks.—On the theory of the formation of volcanic rocks: by *Dr. Streng*. Ann. Ch. Phys. [3] xxxix, 52; Pogg. Ann. xc, 103.
- Volumes.—Considerations on the theory of chemical changes, and on equivalent volumes: by *T. S. Hunt*. Phil. Mag. [4] v, 526.
- Volumetric Analysis.—On a method of volumetric analysis, of very general application: by *R. Bunsen*. Ann. Ch. Pharm. lxxxvi, 265.

W.

- Water.—Hassler's experiments on the expansion of water at various temperatures: by *J. A. Alexander*. Sill. Am. J. xvi, 170.
- On the influence of water in chemical reactions: by *H. Rose*.
5. On the compounds of boracic acid and water with oxide of lead. Pogg. Ann. lxxxvii, 470.
 6. On the compounds of boracic acid and water with oxide of copper. Pogg. Ann. lxxxvii, 587.—Observations in reply to M. Laurent. p. 598.
 - 7, 8, 9. On the compounds of boracic acid and water with protoxide of cobalt, protoxide of nickel and oxide of zinc. Pogg. Ann. lxxxviii, 299.
 10. On the compounds of boracic acid and water with oxide of silver. Pogg. Ann. lxxxviii, 482.
 11. On the action of boracic acid and water on sesquioxide of iron. Pogg. Ann. lxxxix, 473.
- On the influence of water on boracic acid in borates: by *H. Rose*. Chem. Gaz. 1853, 65.
- Report on a memoir by A. Reynoso: "On the action of water on various bodies at high temperatures and pressures": by *M. Dumas*. Compt. rend. xxxvi, 411.
- On the relations between the constitution of salts and the quantity of water contained in them: by *P. Kremers*. Pogg. Ann. lxxxviii, 337.
- Comparative examination of the quantities of water and fat in the brain: by *J. Hauff* and *R. Wagner*. Ann. Ch. Pharm. lxxxv, 42.
- Researches on sulphides decomposable by water; followed by general considerations on the production of sulphurous and siliceous waters: by *M. Fremy*. Compt. rend. xxxvi, 178; J. Pharm. [3] xxiii, 161; Ann. Ch. Phys. [3] xxxviii, 312.

- Water.—On the estimation of water in commercial iodine: by *M. Bolley*. Chem. Gaz. 1853, 119.
- Researches on the absorption of atmospheric water by mineral substances: by *M. Durocher*. Compt. rend. xxxvi, 870.
- Absorption of water by chalk: by *E. J. Chapman*. Phil. Mag. [4] vi, 108.
- Report on a memoir by MM. Verdeil and Rissler, entitled: “Researches on the composition of the soluble matters extracted by water from fertile soils”: by *M. de Gasparin*. Compt. rend. xxxvi, 765.
- On stagnant waters in general and on “*eaux de mares*” in particular: by *M. Marchand*. Compt. rend. xxxvii, 719.
- Researches on the products of the decomposition of rocks under the influence of sulphureous thermal waters: by *M. Bonis*. Compt. rend. xxxvii, 234.
- Note on aerated waters: by *M. Chutin*. J. Pharm. [3] xxiv, 56.
- On the analysis of rain-water collected and distilled in vessels of platinum: by *M. Barral*. Compt. rend. xxxvi, 184.
- On the chemical analysis of rain-water: by *M. Martin*. Compt. rend. xxxvi, 487.
- On the determination of the ammonia contained in waters: by *M. Boussingault*. Compt. rend. xxxvi, 814; Chem. Gaz. 1853, 319.
- On the quantity of ammonia in rain-water collected at a distance from towns: by *Boussingault*. Compt. rend. xxxvii, 207.
- Note on the presence of nickel and cobalt in certain ferruginous waters, and on a process for isolating them: by *O. Henry*. J. Pharm. [3] xxiv, 305.
- Existence of boracic acid in various mineral waters: by *E. Filhol*. Compt. rend. xxxvi, 327; Chem. Gaz. 1853, 113.
- On the presence of boracic acid in the mineral waters of Wiesbaden and Aix-la-Chapelle: by *Fresenius* and *Wildenstein*. Pharm. J. Trans. xii, 548.
- On the analysis of mineral waters containing chloride of magnesium: by *M. Tilmannus*. J. Pharm. [3] xxiii, 234.
- Preliminary notice on mineral water containing iodine: by *P. Bolley*. Ann. Ch. Pharm. lxxxvi, 51.
- Water from the marshes and subsoil of the *Landes* of Gironde: by *M. Fauré*. Ann. Ch. Phys. [3] xxxix, 83.
- Chemical examination of the mineral spring at Langenbrücken in the Grand-Duchy of Nassau: by *F. Wundtleben*. Ann. Ch. Pharm. lxxxvii, 248.
- Note on the presence of the boracic acid in the alkaline sulphureous hot springs of Oletto (Pyrénées Orientales): by *J. Bonis*. Compt. rend. xxxv, 230.
- On the mineral water of Orezza in Corsica: by *M. Poggiade*. J. Pharm. [3] xxiv, 277.
- New analysis of the mineral water of Saxon, in the Canton of Valais, Switzerland: by *P. Morin*. J. Pharm. [3] xxiii, 183.
- Analysis of the sulphur-spring of Serenus: by *A. v. Planta* and *A. Kekulé*. Ann. Ch. Pharm. lxxxvii, 364.
- Analysis of the Sultzmat water (Haut-Rhin). Compt. rend. xxxvi, 495.

- Water.—Mineral waters of Viterbo: by *M. Poggiale*. J. Pharm. [3] xxiii, 114.
 — Analysis of the waters from the deep wells of Westbourne Park, and Russell Square, and the artesian well of the Hanwell Lunatic Asylum: by *C. H. Clark* and *H. Medlock*. Chem. Soc. Qu. J. vi, 115.
 — On the mineral waters of Wiesbaden: by *C. Braun*. J. Pharm. [3] xxiv, 145.
 — Analysis of the Wolkenstein mineral water: by *A. Seyferth*. Ann. Ch. Pharm. lxxxv, 373.
 Wax.—On Pela or Chinese wax, and on the Chinese vegetable fat called *Fat of Stillingia*: by *C. Martins*. J. Pharm. [3] xxiv, 224.
 — On the insect white wax of China: by *D. Hanbury*. Pharm. J. Trans. xii, 476; J. Pharm. [3] xxiv, 136.
 — On peculiar lignites containing wax: by *L. Bruckner*. J. pr. Chem. lvii, 1; J. Pharm. [3] xxiii, 391.
 — On the manufacture of wax candles. Pharm. J. Trans. xii, 399.
 Wheat.—Note on the chemical properties of certain proximate principles of wheat, and of their effect in the nutrition of animals: by *M. Mouriès*. Compt. rend. xxvii, 351.
 Wines.—On the chemical constitution of wines, and on paracitric acid and the paracitrates: by *F. L. Winckler*. Jahrb. f. pr. Pharm. xxv, 65; Chem. Gaz. 1853, 32; J. Pharm. [3] xxiii, 469.
 Wood.—Formation of wood by the bark of dicotyledonous trees: by *A. Trécul*. Compt. rend. xxxvi, 138.
 — On the products of the distillation of wood: by *C. Völckel*. Ann. Ch. Pharm. lxxxvi, 66.
 Wood-spirit.—Action exerted by acids and by alkaline and earthy chlorides on wood-spirit: by *M. Berthelot*. Ann. Ch. Phys. xxxviii, 38.
 Wool.—On the detection of silk, wool, linen, and cotton fibres in textile fabrics: by *G. C. Wittstein*. Pharm. J. Trans. xiii, 181.
 Wurrus.—Importation of Wurrus. Pharm. J. Trans. xiii, 284.

X.

- Xyloïdin.—On the spontaneous decomposition of xyloïdin: by *J. H. Gladstone*. Pharm. J. Trans. xiii, 215.

Z.

- Zinc.—On the estimation of zinc in brass and bronze, and on the separation of oxide of zinc from oxide of copper: by *M. Bobière*. Compt. rend. xxxvi, 224.
 — Note on amalgamated zinc: by *J. Nicklès*. J. Pharm. [3] xxiii, 124.
 — On the analysis of alloys of copper and zinc: by *H. Spirgatis*. J. pr. Chem. lvii, 84; Chem. Gaz. 1853, 260.
 — Note on sulphantimoniate of copper and zinc: by *Prof. Ettling*. Chem. Soc. Qu. J. vi, 140.
 — On the desilverizing of argentiferous lead by means of zinc: by *Dr. Karsten*. Chem. Gaz. 1853, 132.
 — Chloride of zinc as a solvent for copper. Pharm. J. Trans. xiii, 233.
 — On the compounds of boracic acid and water with oxide of zinc: by *H. Rose*. Pogg. Ann. lxxxviii, 303.
 — Preparation of a drying oil for zinc paint. Pharm. J. Trans. xiii, 294.

INDEX.

A.

- Acetate of sesquioxide of iron, 228.
- Acetates, on the, and other compounds of alumina, by W. Crum, 216.
- Acetidin, 286.
- Acetin, 286.
- Acid, acetic, compounds of glycerine with, 286.
 - anhydrous caprylic, 185.
 - pelargonic, 186
 - biethylomeconic, 77.
 - bromopyromeconic, 81.
 - lead-salt of, 81.
 - butyric, compounds of glycerine with, 285.
 - comenamic, 72.
 - ethylomeconic, 74.
 - neutral salts of, 74.
 - kyanurenic, on, by J. Liebig, 113.
 - margaric, compounds of glycerine with, 284.
 - meconamidic, 74.
 - meconic, action of bromine on, 73.
 - coupled ether of, 76.
 - ethers of, 73.
 - on, and its derivatives, by Henry How, 72.
 - mecono-ethylomeconic, 76.
 - oleic, compounds of glycerine with, 284.
 - palmitic, compounds of glycerine with, 284.
 - pyromeconic, action of bromine on, 81.
 - on some salts and decomposition-products of, by James Brown, 78.
 - racemic, new method of separating, into the two tartaric acids, right and left, by L. Pasteur, 277.
 - transformation of the two kinds of tartaric acid into, by L. Pasteur, 277.
 - sinapic, 189.

- Acid, stearic, compounds of glycerine with, 282.
 - on the solid compound obtained by distilling, with lime, T. H. Rowney, 97.
 - sulphotritylic, 288.
 - sulphuric, heat disengaged in the hydration of, 240.
 - tartaric, discovery of inactive, by L. Pasteur, 277.
 - transformation of the two kinds of, into racemic acid, by L. Pasteur, 277.
 - tritylo-sulphocarbonic, 288.
 - valerianic, compounds of glycerine with, 285.
 - heat evolved in the combination of, with anhydrous bases, 246.
 - fatty, heat disengaged in combustion of, 237
 - fixed fatty, compounds of glycerine with, 282
 - with oxide of zinc, 247.
 - mineral, compounds of glycerine with, 287.
 - on anhydrous organic, by L. Chiozza, 184.
 - on the compounds of glycerine with, and on the synthesis of the proximate principles of animal fats, by M. Berthelot, 280.
 - organic, compounds of glycerine with various, 286.
 - tartaric, right and left, new method of separating racemic acid into the two, by L. Pasteur, 277.
 - volatile fatty, compounds of glycerine with, 285.
- Affinity, chemical, researches on, by R. Bunsen, 82.
- Alcohol, castor-oil, on the constitution of, by A. W. Wills, 307.
- propionic, on, by G. Chancel, 287.

- Alcohols and ethers, heat disengaged in combustion of, 236.
- Alcohols, on the acidification of, by oxygen-gas or atmospheric air, and on the use of hydrogen in determining vapour-densities, by R. Railton, 205.
- Alkaloids, cinchona, researches on the, by L. Pasteur, 273.
- vegetable, on some new basic products obtained by the decomposition of, by Henry How, 125.
- Alumina, analysis of the soluble hydrate of, 227.
- bibasic sulphate of, 229.
- bihydrate of, soluble in water, 225.
- hydrate of, from the insoluble binacetate, 228.
- from the soluble binacetate, 225.
- insoluble acetates of, 218.
- on the acetates and other compounds of, by W. Crum, 216.
- precipitate from acetate of, with chloride of sodium, 231.
- soluble acetates of, 222.
- soluble binacetate of, 222.
- Amides, on the, by C. Gerhardt, 193.
- Ammonia, bibasic meconate of, action of chlorine on, 73.
- biethylomeconate of, 77.
- heat evolved in the formation of, 250.
- meconate of, action of heat on, 72.
- bibasic, 72.
- Ammonium and didymium, sulphate of, 270.
- Amylopiperidine, 181.
- hydriodate of, 181.
- Amyl, reaction between morphia and chloride of, 132.
- Amyl-cenanthyl ether, 316.
- Analysis, organic, on the use of gas as fuel in, by A. W. Hofmann, 209.
- Anhydrous bases, combination of acids with, 246.
- Argento-benzo-sulphophenylamide, 196.
- Arragonite and calc-spar, heat disengaged in decomposition of, 239.
- Arsenate of didymium, 267.
- Assay-balance, on an improved, by G. H. Makins, 36.

B.

- Babo and Hirschbrunn, on sinapine, 187.
- Baryta, acid ethylomeconate of, 74.
- heat disengaged in combination of acids with, 247.
- pyromeconate of, 79.

- Bases, anhydrous, heat disengaged in combination of acids with, 246.
- Basic products, on some new, obtained by the decomposition of vegetable alkaloids, by Henry How, 125.
- Baumert, M., on a new oxide of hydrogen, and its relation to ozone, 169.
- Benzoic pelargonate, or pelargonic benzoate, 187.
- valerianate, or valerianic benzoate, 185.
- Benzopiperidine, 178.
- Benzosalicylamide, 196.
- Benzoycin, 286.
- Berthelot, M., on the compounds of glycerine with acids, and on the synthesis of the proximate principles of animal fats, 280.
- Biethylomeconate of ammonia, 77.
- Bromide of tellurethyl, 41.
- Bromine, action of, on meconic acid, 73.
- on pyromeconic acid, 81.
- Brown, James, on some salts and decomposition-products of pyromeconic acid, 78.
- Buff, H., on the law of electrolysis, 47.
- Bunsen, R., on the constitution of iodide of nitrogen, 90.
- researches on chemical affinity, 82.
- Butyridin, 286.
- Butyrins, 285.

C.

- Cahours, A., on piperidine, a new alkali derived from piperine, 175.
- Calc-spar and Arragonite, heat disengaged in decomposition of, 239.
- Caloric equivalents, 254, 255.
- Camphorin, 286.
- Caprylanilide, 186.
- Carbon, heat disengaged in combustion of, 235.
- Carbonate of didymium, 267.
- Castor-oil alcohol, on the constitution of, by A. W. Wills, 307.
- Chalk formation, on deposits of soluble or gelatinous silica in the lower beds of the, by J. T. Way, 102.
- Chance, G., on propionic alcohol, 287.
- Chemical and molecular actions, researches on the quantities of heat disengaged in, by P. A. Favre and J. T. Silbermann, 234.
- Chemical Society, Anniversary Address of the President, 151.
- Annual General Meeting, Report of the Council, 147.
- Chiozza, L., on anhydrous organic acids, 184.

Chiozza, L., researches on the oxygen-radicals, 182.
 Chlorhydrin, 287.
 Chloride of didymium, 265.
 Chloride of sodium, method of determining urea in urine containing, 25.
 ——— on a new method for the determination of, in urine, by J. Liebig, 1.
 ——— preparation of normal solution of, for determining the mercury in a solution of the protonitrate, 15.
 ——— preparation of test-liquor for the determination of, 10.
 Chloride of stanethylium, 60.
 Chlorine, action of, on bibasic meconate of ammonia, 73.
 ——— heat produced by the combination of metals with, 247.
 ——— quantitative determination of, in neutral liquids by means of protoxide of mercury, 7.
 Chromium, oxide of, on the behaviour of some oxides with caustic potash in the presence of, by A. B. Northcote and A. H. Church, 54.
 Church, A. H., and A. B. Northcote, on the action of caustic potash on the phosphates, 53.
 ——— on the behaviour of some oxides with caustic potash in the presence of oxide of chromium, 54.
 Cinchonine, 274.
 Cinchonidine and quinidine, action of heat on, 276.
 Clarke, C. H., and H. Medlock, analysis of the waters from the deep wells of Westbourne Park and Russell Square, and of the Artesian well of the Hanwell Lunatic Asylum, 115.
 Codeine, action of iodide of ethyl upon, 134.
 Copper, heat evolved in the combination of acids with oxide of, 247.
 ——— pyromeconate of, 80.
 ——— sulphantimoniate of, and zinc, by Professor Ettling, 140.
 Crum, Walter, on the acetates and other compounds of alumina, 216.
 Cumo-benzo-sulphophenylamide, 196.
 Cumo-salicylamide, 196.
 Cumyl, 183.
 Cumyloxyperidine, 178.

D.

Decomposition, heat disengaged in certain phenomena of chemical, and in modifications by dimorphism, 238.

Dibenzophenylamide, 196.
 Dibenzo-sulphophenylamide, 196.
 Dibutyriu, 286.
 ——— researches on, and its principal compounds, by C. Marignac, 260.
 Didymium and ammonium, sulphate of, 270.
 ——— and potassium, sulphate of, 272.
 ——— and sodium, sulphate of, 371.
 ——— arseniate of, 267.
 ——— carbonate of, 267.
 ——— chloride of, 265.
 ——— metallic, 262.
 ——— nitrate of, 266.
 ——— oxalate of, 272.
 ——— peroxide of, 264.
 ——— phosphate of, 266.
 ——— protoxide of, 262.
 ——— sulphate of, 269.
 ——— sulphide of, 264.
 ——— sulphite of, 268.
 Dimorphism, heat disengaged in certain phenomena of chemical decomposition, and in modifications by, 238.
 Diolein, 285.
 Dipalmitin, 284.
 Distearin, 283.
 Divalerin, 285.

E.

Eight-carbon ether, 314.
 Electric current, quantities of heat evolved in chemical actions produced by the, 260.
 Electrolysis, on the law of, by H. Buff, 47.
 Ethers and alcohols, heat disengaged in combustion of, 236.
 ——— compound, heat disengaged in combustion of, 237.
 ——— on, intermediate between the ænanthyllic and the methylic, ethylic, and amylic series, by A. W. Wills, 307.
 Ethyl, action of iodide of, upon codeine, 134.
 ——— upon morphia, 126.
 ——— iodide of, action of tin upon, 58.
 Ethylcodeine, action of iodide of ethyl on, 137.
 Ethyl-ænanthyl ether, 312.
 Ethylomeconate of baryta, acid, 74.
 ——— of silver, acid, 74.
 Ethyloxyperidine, 179.
 ——— hydrochlorate of, 180.
 Ethyl-urea, piperidic, 178.

Ettling, note on sulphantimoniate of copper and zinc, 140.

F.

Fats, animal, on the compounds of glycerine with acids, and on the synthesis of the proximate principles of, by M. Berthelot, 280.

Favre, P. A., and J. T. Silbermann, researches on the quantities of heat disengaged in chemical and molecular actions, 234.

Ferguson, W., on the increase in weight of molasses casks, occasionally arising from absorption, 122.

Ferric oxide, pyromeconate of, 80.

Frankland, E., on a new series of organic bodies containing metals, 57.

Frankland, E., and W. J. Ward, on an improved apparatus for the analysis of gases, 197.

G.

Gas, on the use of, as fuel in organic analysis, by A. W. Hofmann, 209.

Gases, apparatus for collecting, over water or mercury, by W. M. Williams, 44.

— heat disengaged by the solution of, in water, 241.

— heat evolved in the condensation of, by porous bodies, 251.

— heat evolved or absorbed by the sudden compression or expansion of various, 251.

— on an improved apparatus for the analysis of, by E. Frankland and W. J. Ward, 197.

— table of the thermometrical results produced by sudden change of volume in, 253.

Gerhardt, C., on the amides, 193.

Gladstone, J. H., on a compound sulphate of potash and soda, 106.

Glycerine, compounds of, with acetic acid, 286.

— with butyric acid, 285.

— with margaric acid, 284.

— with mineral acids, 287.

— with oleic acid, 284.

— with palmitic acid, 284.

— with stearic acid, 282.

— with valerianic acid, 285.

— with various organic acids, 286.

Glycerine, on the compounds of, with acids and on the synthesis of the proximate principles of animal fats, by M. Berthelot, 280.

Gold, double hydrochlorate of sincline and, 190.

H.

Heat, action of, on meconate of ammonia, 72.

— researches on the quantities of, disengaged in chemical and molecular actions, by P. A. Favre and J. T. Silbermann, 234.

— evolved in the condensation of gases by porous bodies, 251.

— in the formation of ammonia, 250.

— or absorbed by the sudden compression or expansion of various gases, 251.

— disengaged by the chemical action of the solar rays, 259.

— by the combustion of acids with anhydrous bases, 246.

— by the solution of gases in water, 241.

— by the solution of salts in water, 241.

— in certain phenomena of chemical decomposition and in changes by demorphism, 238.

— in rapid combustion, 234.

— in the formation of salts, 242.

— in the hydration of sulphuric acid, 240.

— produced by the combination of metals with oxygen, chlorine, iodine, &c., 247.

— quantities of, evolved in chemical actions produced by the electric current, 260.

Heats, specific and latent, of various bodies, 250.

Hirschbrunn, M., and M. Babo, on sinapine, 187.

Hofmann, A. W., on the use of gas as fuel in organic analysis, 209.

How, Henry, on meconic acid and its derivatives, 72.

— on some new basic products, obtained by the decomposition of vegetable alkaloids, 125.

Hydrargyromethylum, 65.

Hydrate of alumina, soluble in water, 225.

Hydriodate of amyloperidine, 181.

— of piperidine, 177.

- Hydrocarbons, heat disengaged in combustion of, 236.
 Hydrochlorate, double, of sincaline and gold, 190.
 — of sincaline and platinum, 190.
 — of ethyloperidine, 180.
 — of piperidine, 176.
 Hydrogen, on a new oxide of, and its relation to ozone, by M. Baumert, 169.
 — on the use of, in determining vapour-densities, and on the acidification of alcohols by oxygen-gas or atmospheric air, by R. Railton, 205.

I.

- Iodide of ethyl, action of tin upon, 58.
 — of methyl, action of mercury upon, 65.
 — action of zinc upon, 62.
 — of nitrogen, on the constitution of, by R. Bunsen, 90.
 — of stanethylium, 59.
 — of tellurethyl, 42.
 Iodine, heat produced by the combination of metals with, 247.
 — on the general distribution of, by Stevenson Macadam, 166.
 Iron, acetate of sesquioxide of, 228.

L.

- Lead, oxide of, combination of acids with, 247.
 — pyromeconate of, 80.
 Lead-salt of bromopyromeconic acid, 81.
 Liebig, J., note on Thierschite, 112.
 — on kyanurenic acid, 113.
 — on some compounds of urea, and on a new method for the determination of chloride of sodium and of urea in urine, 1.
 Lieshing, F., on the mode of estimating the value of red prussiate of potash, 31.
 Lime, combination of acids with, 246.
 — pyromeconate of, 79.

M.

- Macadam, Stevenson, on the general distribution of iodine, 166.
 Magnesia, pyromeconate of, 79.
 Makins, G. H., on an improved assay-balance, 36.

- Margarins, 284.
 Marignac, C., researches on didymium and its principal compounds, 260.
 Meconate of ammonia, bibasic, 72.
 — action of chlorine on, 73.
 Medlock, H., and C. H. Clarke, analysis of the waters from the deep wells of Westbourne Park and Russell Square, and the artesian well of the Hanwell Lunatic Asylum, 115.
 Mercury, action of, upon iodide of methyl, 65.
 — compounds of protoxide of, with urea, 2—4.
 — compounds of urea with protoxide of, 5—7.
 — determination of protoxide of, in a solution of nitrate of, 14.
 — preparation of nitrate of protoxide of, 8.
 — preparation of normal solution of chloride of sodium for determining the, in a solution of the protonitrate, 15.
 — preparation of solution of, for the precipitation of urea in urine, 21.
 — quantitative determination of chlorine in neutral liquids by means of protoxide of, 7.
 Metals, heat produced by the combination of, with oxygen, chlorine, iodine, &c., 247.
 — on a new series of organic bodies containing, by E. Frankland, 57.
 Methyl, action of iodide of, upon morphia, 130.
 — iodide of, action of mercury upon, 65.
 — action of zinc upon, 62.
 Methyl-cenanthyl ether, 314.
 Methyloperidine, 179.
 Methyl-urea, piperidic, 178.
 Molasses casks, on the increase in the weight of, occasionally arising from absorption, by W. Ferguson, 122.
 Molecular and chemical actions, researches on the quantities of heat disengaged in, by P. A. Favre and J. T. Silbermann, 234.
 Monobutylin, 285.
 Monomargarin, 284.
 Monopalmitin, 284.
 Monostearin, 282.
 Monovalerin, 285.
 Morphia, action of iodide of ethyl upon, 126.
 — methyl upon, 130.
 — and chloride of amyl, reaction between, 132.

N.

- Nine-carbon ether, 312.
 Nitrate of didymium, 266.
 — of piperidine, 177.
 — of urea, compounds of, with protoxide of mercury, 5—7.
 Nitrogen, iodide of, on the constitution of, by R. Bunsen, 90.
 — on two new methods for the determination of, in organic and inorganic compounds, by Dr. Maxwell Simpson, 289.
 Northcote, A. B., and A. H. Church, on the action of caustic potash on the phosphates, 53.
 — on the behaviour of some oxides with caustic potash in the presence of oxide of chromium, 54.

O.

- Oleins, 284.
 Organic bodies, on a new series of, containing metals, by E. Frankland, 57.
 Oxalate of didymium, 272.
 — of oxide of tellurethyl, 43.
 — of piperidine, 177.
 Oxide of stannethylum, 59.
 — of tellurethyl, 43.
 Oxides of didymium, 262.
 — on the behaviour of some, with caustic potash in the presence of oxide of chromium, by A. B. Northcote and A. H. Church, 54.
 Oxybromide of tellurethyl, 41.
 Oxychloride of tellurethyl, 41.
 Oxygen, heat produced by the combination of metals with, 247.
 — on the acidification of alcohols by, or atmospheric air; and on the use of hydrogen in determining vapour-densities, by R. Railton, 205.
 Oxygen-radicals, researches on the, by L. Chiozza, 182.
 Oxyiodide of tellurethyl, 42.
 Ozone, on a new oxide of hydrogen, and its relation to, by M. Baunert, 169.

P.

- Palmitin, 284.
 Pasteur, L., researches on the cinchona alkaloids, 273.
 — transformation of the two kinds of tartaric acid into racemic acid. Discovery of inactive tartaric acid. New method of separating racemic acid into the two tartaric acids, right and left, 277.
 Pelargonic benzoate, or benzoic pelargonate, 187.

Phenylamide, dibenzo- (Dibenzanilide), 197.

- Phosphate of didymium, 265.
 Phosphates, on the action of caustic potash, on the, by A. B. Northcote and A. H. Church, 53.
 Piperidic ethyl-urea, 178.
 — methyl-urea, 178.
 — urea, 177.
 Piperidine, hydriodate of, 177.
 — hydrochlorate of, 176.
 — nitrate of, 177.
 — on, a new alkali derived from piperine, by A. Cahours, 175.
 — oxalate of, 177.
 — sulphate of, 177.
 — sulphocarbonate of, 178.

Platinum, double hydrochlorate of sinealine and, 190.

Potash, caustic, on the action of, on the phosphates, by A. B. Northcote and A. H. Church, 53.

— on the behaviour of some oxides with, in the presence of oxide of chromium, by A. B. Northcote and A. H. Church, 54.

— mode of estimating the value of red prussiate of, by F. Liesching, 31.

— on a compound sulphate of, and soda, by J. H. Gladstone, 106.

Potassium and didymium, sulphate of, 272.

Proceedings at the Meetings of the Chemical Society, 54, 141, 317.

Prussiate, red, of potash, mode of estimating the value of, by F. Liesching 31.

Pyromecconate of baryta, 79.

— of copper, 80.

— of ferric oxide, 80.

— of lead, 80.

— of lime, 79.

— of magnesia, 79.

— of strontia, 79.

Q.

Quinicine, 274.

Quinidine, 275.

— and cinchonidine, action of heat on, 276.

Quinoidine, 276.

R.

Railton, R., on the use of hydrogen in determining vapour-densities, and on the acidification of alcohols by oxygen-gas or atmospheric air, 205.

Report of the Council, March 30th, 1853, 141.

— Treasurer's, 148.

Rowney, T. H., on the solid compound obtained by distilling stearic acid with lime, 97.

S.

Salicylamide, benzo-, 196.

— cumo-, 196.

Saline compounds, heat disengaged in the formation of, 257.

Salts, solution of, in water, 241.

Sebin, 286.

Silbermann, J. T. and P. A. Favre, researches on the quantities of heat disengaged in chemical and molecular actions, 234.

Silica, soluble or gelatinous, on deposits of, in the lower beds of the chalk formation, by J. T. Way, 102.

Silver, acid ethylomeconate of, 74.

— compound of oxide of, with urea, 4.

— on, by MM. Babo and Hirschbrunn, 187.

Simpson, M., on two new methods for the determination of nitrogen in organic and inorganic compounds, 289.

Sincaline, 189.

Soda, on a compound sulphate of potash and, by J. H. Gladstone, 106.

Sodium and didymium, sulphate of, 271.

— chloride of, precipitate from acetate of alumina with, 231.

— on a new method for the determination of chloride of, in urine, by J. Liebig, 1.

Solar rays, heat disengaged by the chemical action of the, 259.

Stanamylum, 62.

Stanethylum, 60.

— chloride of, 60.

— iodide of, 59.

— oxide of, 59.

— sulphide of, 60.

Stannethylum, 62.

Stearins, 282.

Strontia, combination of acids with, 247.

— pyromecconate of, 79.

Sulphate of alumina, bibasic, 229.

— of didymium, 269.

— and ammonium, 270.

— and sodium, 271.

— of oxide of tellurethyl, 43.

— of piperidine, 177.

Sulphide of didymium, 264.

— of stanethylum, 60.

Sulphite of didymium, 268.

— and potassium, 272.

Sulphocarbonate of piperidine, 178.

Sulphophenylamide, argento-benzo-, 196.

— benzo-, 196.

— cumo-benzo-, 196.

— dibenzo-, 196.

Sulphur, heat disengaged in combustion of, 238.

T.

Tellurethyl, on some new compounds of, by Wöhler, 40.

— bromide of, 41.

— iodide of, 42.

— oxalate of oxide of, 43.

— oxide of, 43.

— oxybromide of, 41.

— oxychloride of, 41.

— oxyiodide of, 42.

— sulphate of oxide of, 43.

Test-liquor, preparation of, for the determination of chloride of sodium, 10.

Tetramargarin, 284.

Tetrapalmitin, 284.

Tetratearin, 283.

Thierschite, note on, by J. Liebig, 112.

Tin, action of, upon iodide of ethyl, 58.

Trityl, hydrate of, 287.

Twelve-carbon ether, 316.

U.

Urea, on some compounds of, and on a new method for the determination of chloride of sodium and of urea in urine, by J. Liebig, 1.

— compound of, with oxide of silver, 4.

— compounds of nitrate of, with protoxide of mercury, 5—7.

— with protoxide of mercury, 2—4.

— method for the determination of, in urine, 18.

— method of determining, in urine containing chloride of sodium, 25.

— piperidic, 177.

— preparation of solution of mercury, for the precipitation of urea in urine, 21.

V.

Valerianilide, 185.

Valerianic benzoate, or benzoic valerianate, 185.

Valerins, 285.

W.

Ward, W. J., and E. Frankland, on an improved apparatus for the analysis of gases, 197.

Waters, analysis of the, from the deep wells of Westbourne Park and Russell Square, and the artesian well of the Hanwell Lunatic Asylum, by C. H. Clarke and H. Medlock, 115.

Way, J. T., on deposits of soluble or gelatinous silica in the lower beds of the chalk formation, 102.

Williams, W. M., description of an apparatus for collecting gases over water or mercury, 44.

Wills, A. W., on ethers intermediate between the ænanthylic and the methylic, ethylic, and amylic series, and on the constitution of castor-oil alcohol, 307.

Wöhler, on some new compounds of tellurethyl, 40.

Z.

Zinc, action of, upon iodide of methyl, 62.

— heat evolved in the combination of acids with oxide of, 247.

— sulphantimoniate of, and copper, by Professor Ettling, 140.

Zincamylum, 64.

Zincethylum, 63.

Zincmethylum, 63.

END OF VOL. VI.

L O N D O N :

Printed by Schulze and Co., 13, Poland Street.

QD

1

C6

v.5-6

cop.3

Chemical Society, London
Journal

*Physical &
Applied Sci.
Serials*

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

STORAGE

